Folks,

Main Propulsion Plant DD445 and 692 Classes and Converted Types, Operation Manual, Revision 1, Jan 1946 was created just after WW II. It describes the peak of WW II US destroyer propulsion technology.

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MAIN PROPULSION PLANT

DD445 and 692 CLASSES

AND

CONVERTED TYPES

OPERATION MANUAL

U. S. NAVY
BUREAU OF SHIPS

REVISION 1
Jan. 1946

RESTRICTED

NAVY DEPARTMENT

BUREAU OF SHIPS

Washington, D. C.

This Manual is published by authority of the Chief of the Bureau of Ships, and is approved and issued to the service for guidance in the training of the personnel concerned.

E. L. COCHRANE,
Vice Admiral, U.S. N.,
Chief, Bureau of Ships.

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ACKNOWLEDGMENTS

Acknowledgments are due to the several individuals and activities instrumental in the preparation of this Manual. The basic text was prepared under the supervision of the Assistant Supervisor of Shipbuilding, Staten Island, Lt. Comdr. L. L. Habryl, USNR.; primarily by Mr. S. M. Arwine. with the advice and assistance of Lieut. R. S. Laing, USNR, and Lieut. E. A. O'Mara. USNR; and with the specific approval of the Supervisor of Shipbuilding, New York, Rear Admiral J. M. Irish. USN. Text and illustrations have been checked and revised by the Destroyer Ship Desk and cognizant Technical Sections of the Bureau of Ships.

The first reprinting, January 1946, includes minor revisions in view of major authorized alterations to date, together with desirable additions in text and certain illustrations.

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Version 1.01, 16 May 05

Section I

INTRODUCTION

As the speed of construction of destroyers increased, the percentage of experienced engineering personnel available for assignment to these newly constructed destroyers became smaller and smaller, and the time available for these personnel to familiarize themselves with their particular installations became less and less. Because of these facts it was decided that the Office of the Supervisor of Shipbuilding, U. S. N., Staten Island, must establish a training course to enable the prospective engineering crews to more quickly learn the operation of their engineering plants. In the early stages, the Instructor of this course made notes and sketches to aid in the instruction. As these notes increased it became apparent that they could be collated and placed in coherent form, to form an instruction book which could be used by engineer officers afloat for instruction of new members of their crew. This manual is a compilation and outgrowth of these notes. Its purpose is to present to engineering personnel of all ratings the complete cycle of operation of the closed feed system in a manner which can be easily understood by all, from firemen to engineer officers. In order to make this possible a great amount of the detail and highly technical explanation presented in the regular machinery instruction books have been eliminated, and special operating notes have been incorporated. The object has been to present the operating action within the machinery rather than the details of construction of the machinery. The premise upon which the construction of this book is based is that the prospective ship's force does not have a comprehensive picture of the operation of the plant as a whole and does not fully understand the interdependence of each part of the

1. The steam cycle is composed of a series of systems.

2. These systems may be either an integral part of the main cycle or furnish a service to some system of the main cycle.

3. These systems are composed of elements, the proper operation of which will insure proper operation of the system.

4. Proper operation of the elements composing this system depends upon proper operation of the systems furnishing service.

5. Proper operation of all systems in the steam cycle will insure proper operation of the machinery plant as a whole.

Using the steam cycle as a base, each system has been broken down into its elements and after discussion of each element in chronological order they are all connected together by a discussion of the piping system. To tie the steam cycle together. the systems are presented in their chronological order, with the systems furnishing service presented in connection with the proper part of the steam cycle. Most of the information presented in this manual is available in the manufacturers' instruction books, in the Bureau of Ships Manual or in the Gibbs and Cox Appendices (1) (Notes on Operation), (2) (Operation for Maximum Economy) and Principal Engineering Piping Systems and Related Equipment for these classes of destroyers. However, it is here presented in chronological form

plant upon each other part. To present this comprehensive picture, it is necessary to present the plant from the point of view of the complete steam cycle of the closed feed system. To establish this method the following basic facts must first be recognized:

and in such a manner that it can be more easily understood and oriented by the student. Little attention has been paid to the auxiliaries not directly connected to the main propulsion plant. These auxiliaries are relatively few and are operated only by a few men on board ship. Because so few men are involved, detailed instruction in the operation of these auxiliary units can easily be accomplished from the manufacturers' instruction books. This text has been written specifically for the DD445 and DD692 class destroyers of the U. S. Navy and applies in detail

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to all destroyers and converted types of those classes. While it does apply, in general, to all ships whose engineering plants follow the pressure closed feed system, it is not intended to be a description of any plant except those above designated. This book has been written with the original assumption that students will have had some

basic training in marine engineering operation and, therefore, must be at least partially grounded in engineering fundamentals. A thorough and complete knowledge of this text should enable any student, who has a previous engineering background, to successfully operate any ship employing the pressure closed feed system.

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Section II

ARRANGEMENT OF MACHINERY

1. GENERAL DISCUSSION

Machinery in the engineering plants of the DD445 and DD692 Class destroyers is so arranged that the forward fireroom and the forward engineroom can be operated together as a completely independent engineering plant, as can the after fireroom and after engineroom. This means, then, that all machinery necessary to the operation of the main propulsion plant must be duplicated in each engineroom and fireroom, and that means must be provided to positively separate the systems in the two plants. The same thing can be said of the machinery necessary to the operation of the ship's service generators. Various auxiliary units, not directly related to the operation of the main propulsion plant or the generating plants, are located throughout the engineering spaces wherever space is available. The following sketches show the relative location of the units of machinery in the engineering spaces. In order to properly show-this arrangement, it has been necessary to break each plant down into upper and lower levels. It will be noted that there are considerable differences between the arrangements of the DD445 Class and the DD692 Class. This by no means indicates any difference in the operating principles of these two plants. A comparison between the two will show that the machinery necessary to the operation of the main plant of both classes is exactly the same.

2. LIST OF MACHINERY

Grouping together one engineroom and its corresponding fireroom as a "plant" the following machinery appears in each plant of both the DD445 Class and the DD692 Class destroyers:

EACH FIREROOM

Boilers	2 enclosed draft, superheat control by separately fired superheater.
Blowers	4 horizontal, turbine driven, propeller type.
Fire and bilge pump	1 vertical simplex, double-acting reciprocating.
Emergency feed pump	I vertical simplex, double-acting reciprocating.
Fuel oil transfer and booster pump	1 vertical rotary gear, turbine driven.
Port and cruising fuel oil service pump.	1 vertical variable stroke, motor driven. (These pumps are not installed in all ships but the foundations and fittings are installed to provide for future installation of the pumps.)

Fuel oil service pumps	2 vertical rotary gear, turbine-driven.
Fuel oil hand pump	1 horizontal gear, hand-driven.

EACH ENGINEROOM

Cruising turbine	1 pressure-velocity compounded, impulse.
High pressure turbine	1 pressure-velocity compounded, impulse.
Low pressure and astern turbines.	1 double-flow, pressure-compounded, astern turbines. The low pressure turbine is double flow in all installations, but in some is pressure compounded, impulse, and in others is reaction.
Main condenser	1 single pass.
Main reduction gear	1 double reduction, double helical, locked train type gear.
Main air ejector	1 two-stage, condensing.
Deaerating feed tank	1 in DD445 class either the Cochrane or Elliott types. In DD692 class all are the Elliott type.
Main circulating pump	1 propeller type, turbine-driven.
Ship's service generator	1 in DD445 class, 290 kw., geared turbine-driven, and in DD692 class, 450 kw. geared turbine-driven,

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Auxiliary air ejector	1 two-stage, condensing.
Lubricating oil purifier	1
Lubricating oil cooler	1 single-pass, reverse flow.
Lubricating oil service pumps	2 vertical rotary gear. (Some ships of DD445 class have two turbine-driven pumps and some have one turbine-driven and one motor-driven pump. All ships of the DD692 class have two turbine-driven pumps.)
Main feed pumps	2 horizontal, turbine-driven, multistage, centrifugal.
Main feed booster pumps	2 vertical, single-stage, centrifugal. (DD445 class has one turbine-driven and one motor-driven, and the DD692 class has both turbine-driven)
Main condensate pumps	2 vertical two-stage, centrifugal. (DD445 class has one turbine-driven and one motor-driven, and DD692 class has both turbine-driven.)
Fire and bilge pump	1 vertical, simplex, double-acting, reciprocating.
Fire-and-flushing pump	1 horizontal, centrifugal, motor-driven.
Auxiliary condenser	1 two pass.
Auxiliary condensate pump	1 vertical, centrifugal, two-stage, motor-driven.
Auxiliary feed booster pump	1 vertical, centrifugal, single-stage, motor-driven.

Auxiliary circulating pump	1 horizontal, centrifugal, motor-driven.

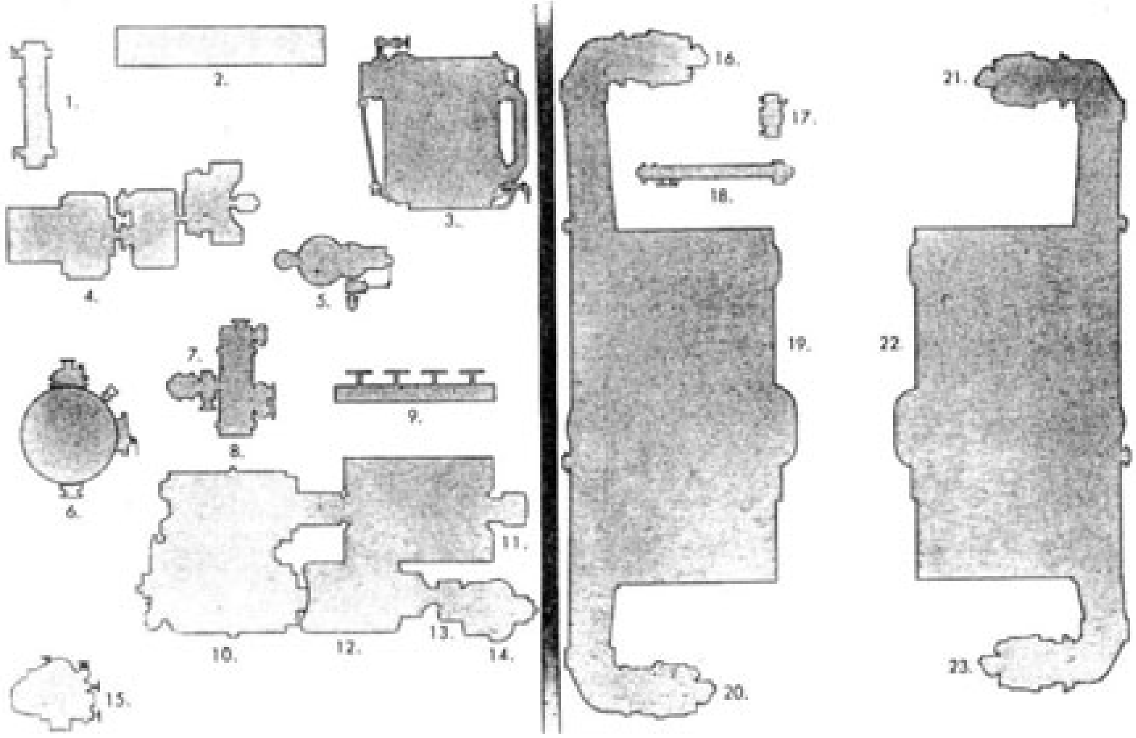
Below is listed the additional auxiliary machinery for the DD445 class, with the space in which it is located indicated:

High-pressure air compressor	1 No. 2 fireroom-four-stage, reciprocating, driven by a geared turbine.
Distilling plant	1 No. 1 engine room-Griscom Russell Soloshell-2 effect rated capacity, 12,000 gallons per day. All pumps auxiliary to this unit are horizontal, centrifugal, motor driven.
Fresh water pumps	2 No. 1 engineroom-horizontal, centrifugal, motor driven.
Low-pressure air compressor	1 No. 2 engineroom-two-stage V-type, motor-driven.
Diesel fuel oil purifier	1 No. 2 engineroom.
Diesel oil supply and transfer pump	1 No. 2 engineroom-horizontal, rotary gear, motor-driven.

Below is listed the additional auxiliary machinery for the DD692 class, with the space in which it is located indicated:

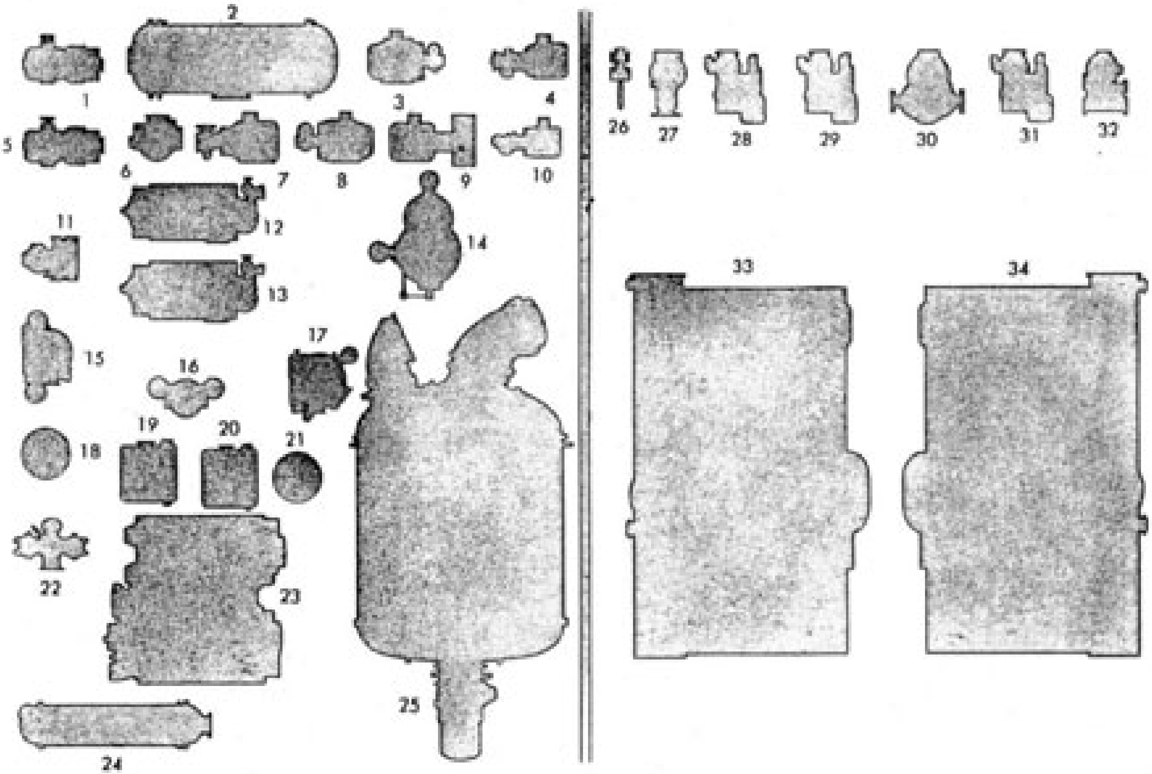
High pressure air compressor	1 No. 2 fireroom-four-stage, reciprocating, geared turbine-driven.
Distilling plant	1 No. 1 engineroom-Griscom Russell Soloshell, double effect-rated capacity 12,000 gal. per day. All pumps auxiliary to this unit are horizontal centrifugal, motor-driven.
Distilling plant	1 No. 2 engineroom-same as above except that capacity is 4,000 gal. per day.
Low-pressure air compressor	1 No. 2 engineroom-two stage, V-type, motor-driven.
Fresh-water pumps	2 one in each engineroom-horizontal, centrifugal, motor-driven.
Shaft driven lubricating oil service pumps	1 vertical rotary gear chain drive from the main shaft in No. 1 engineroom; 1 horizontal rotary gear chain drive from the main shaft in No. 2 engineroom.

It will be noted that the Diesel fuel oil pump and purifier do not appear on this list for the DD692 class. This is because they have here been removed from the engineroom and placed in the gland compartment (C-3E). In the DD445 class only one Diesel generator is installed, and that in the Diesel generator room forward. In the DD692 class two Diesel generators are installed, each in its own space one forward and one aft.



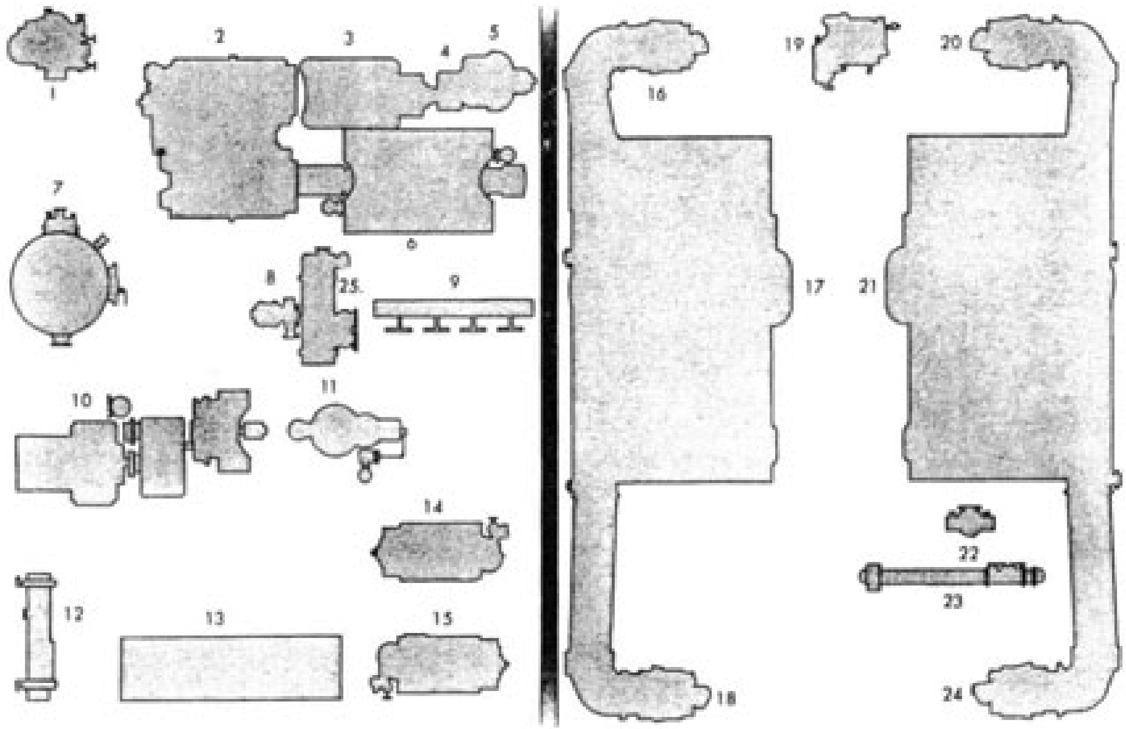
1. AUXILIARY AIR EJECTOR
2. MAIN SWITCHBOARD
3. EVAPORATING PLANT
4. MAIN GENERATOR
5. MAIN CIRCULATOR
6. DEAERATING TANK
7. GLAND EXHAUSTER
8. MAIN AIR EJECTOR
9. MAIN GAUGE BOARD
10. MAIN REDUCTION GEAR
11. LOW PRESSURE TURBINE
12. HIGH PRESSURE TURBINE
13. CRUISING REDUCTION GEAR
14. CRUISING TURBINE
15. LUBRICATING OIL PURIFIER
16. #4 BLOWER
17. FUEL OIL STRAINER
18. FUEL OIL HEATERS
19. #2 BOILER
20. #3 BLOWER
21. #2 BLOWER
22. #1 BOILER
23. #1 BLOWER

ARRANGEMENT OF MACHINERY
UPPER LEVEL - FORWARD PLANT
445 CLASS
FIG. 1



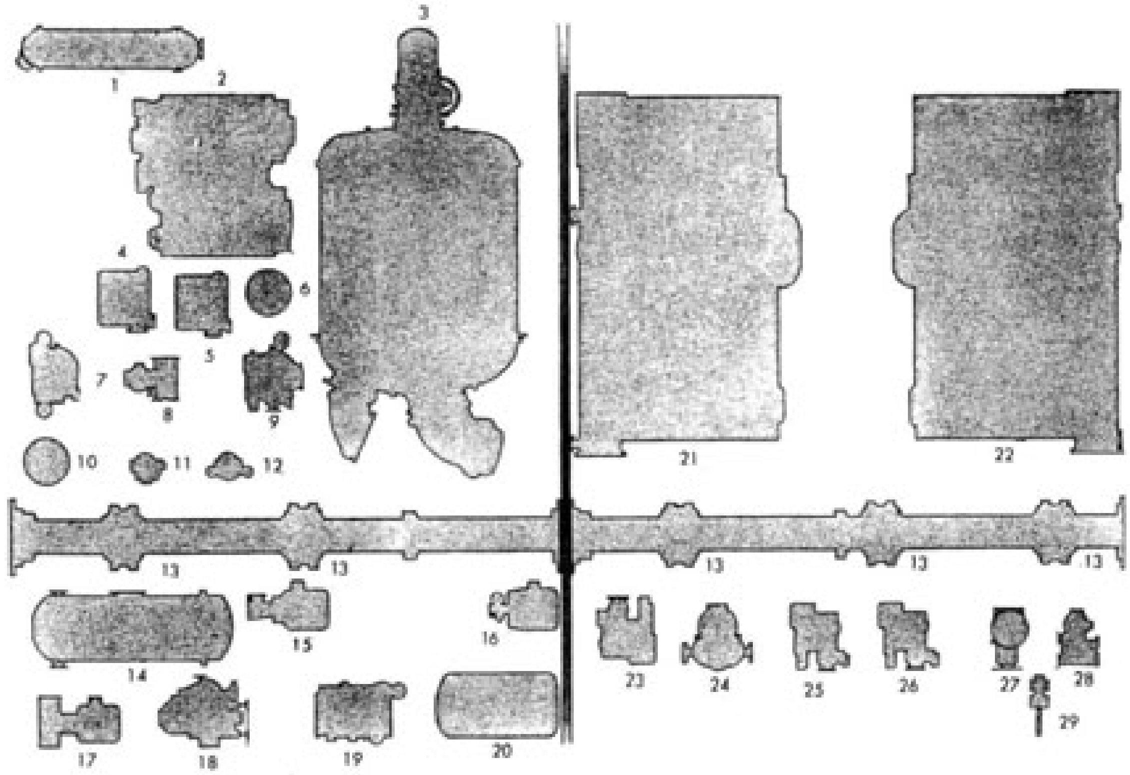
1. FRESH WATER PUMP
2. AUXILIARY CONDENSER
3. DISTILLING CONDENSER CIRCULATING PUMP
4. EVAPORATOR BRINE PUMP
5. FRESH WATER PUMP
6. AUXILIARY CONDENSATE PUMP
7. AUXILIARY CIRCULATOR PUMP
8. FIRE AND FLUSHING PUMP
9. 1ST EFFECT DRAIN PUMP
10. DISTILLER CONDENSER COMPENSATE PUMP
11. #2 FIRE AND BILGE PUMP
12. #2 MAIN FEED PUMP
13. #1 MAIN FEED PUMP
14. MAIN CIRCULATOR
15. STEAM FEED BOOSTER PUMP
16. AUXILIARY FEED BOOSTER PUMP
17. STEAM CONDENSATE PUMP
18. ELECTRIC FEED BOOSTER PUMP
19. STEAM LUBRICATING OIL SERVICE PUMP #2
20. STEAM LUBRICATING OIL SERVICE PUMP #1
21. ELECTRIC CONDENSATE PUMP
22. LUBRICATING OIL STRAINER
23. MAIN REDUCTION GEAR
24. LUBRICATING OIL COOLER
25. MAIN CONDENSER
26. HAND FUEL OIL PUMP
27. PORT AND CRUISING FUEL OIL PUMP
28. #2 FUEL OIL SERVICE PUMP
29. #1 FUEL OIL SERVICE PUMP
30. EMERGENCY FEED PUMP
31. #1 FUEL OIL BOOSTER PUMP
32. #1 FIRE AND BILGE PUMP
33. #2 BOILER
34. #1 BOILER

ARRANGEMENT OF MACHINERY
LOWER LEVEL - FORWARD PLANT
445 CLASS
FIG. 2



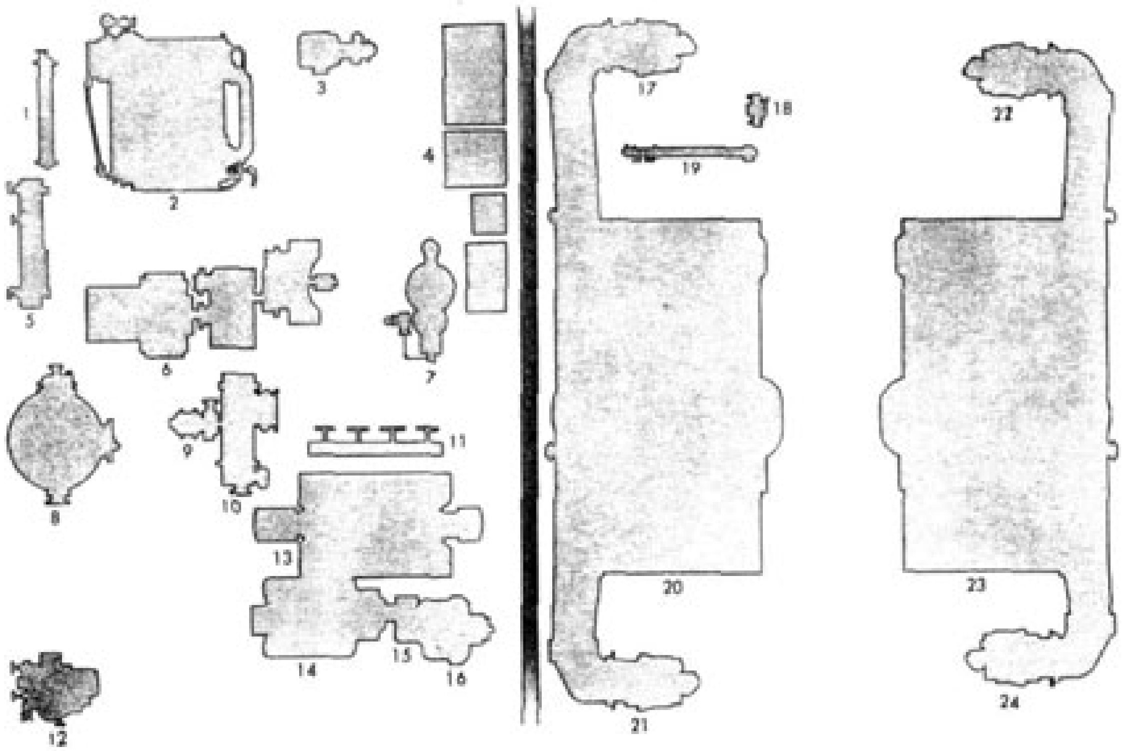
1. LUBRICATING OIL PURIFIER
2. MAIN REDUCTION GEAR
3. HIGH PRESSURE TURBINE
4. CRUISING REDUCTION GEAR
5. CRUISING TURBINE
6. LOW PRESSURE TURBINE
7. DEAERATING TANK
8. GLAND EXHAUSTER
9. MAIN GAUGE BOARD
10. MAIN GENERATOR
11. MAIN CIRCULATOR PUMP
12. AUXILIARY AIR EJECTOR
13. SWITCHBOARD
14. #4 MAIN FEED PUMP
15. #3 MAIN FEED PUMP
16. #8 BLOWER
17. #4 BOILER
18. #7 BLOWER
19. HIGH PRESSURE AIR COMPRESSOR
20. #6 BLOWER
21. #3 BOILER
22. FUEL OIL STRAINER
23. FUEL OIL HEATERS
24. #5 BLOWER
25. MAIN AIR EJECTOR

ARRANGEMENT OF MACHINERY
UPPER LEVEL - AFTER PLANT
445 CLASS
FIG. 3



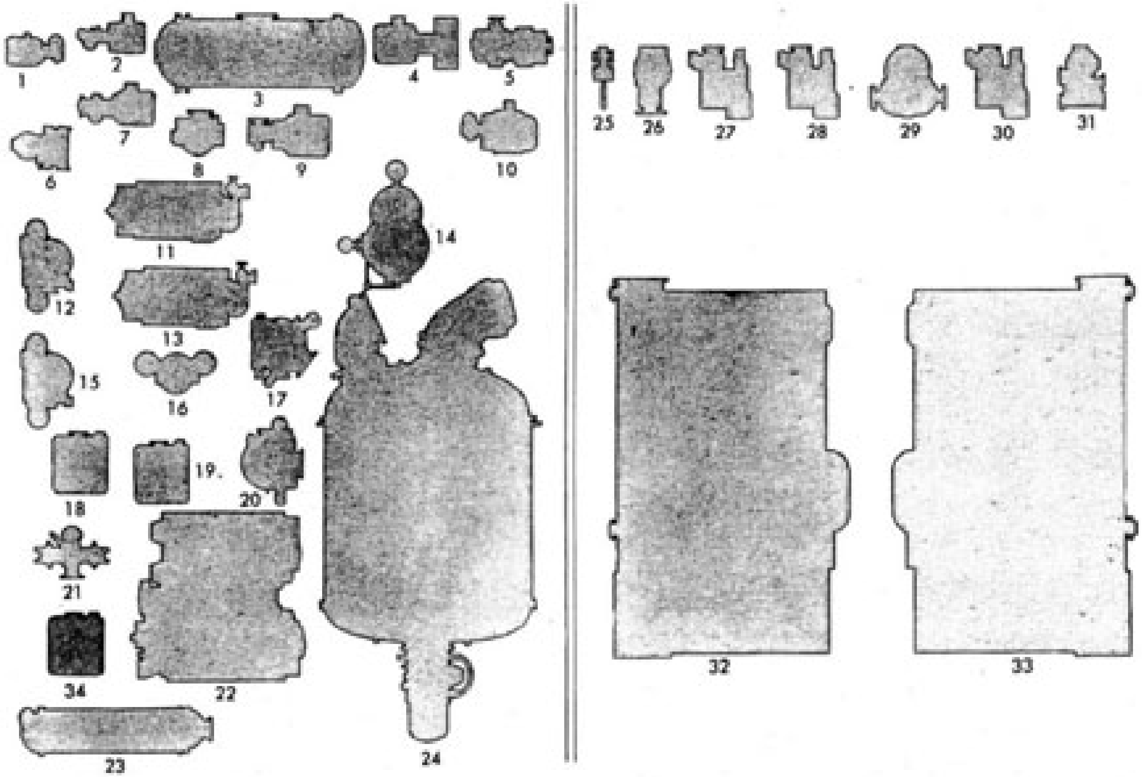
1. LUBRICATING OIL COOLER
2. MAIN REDUCTION GEAR
3. MAIN CONDENSER
4. STEAM LUBRICATING OIL PUMP
5. STEAM LUBRICATING OIL PUMP
6. ELECTRIC CONDENSATE PUMP
7. STEAM BOOSTER PUMP
8. FIRE AND BILGE PUMP
9. STEAM CONDENSATE PUMP
10. ELECTRIC BOOSTER PUMP
11. AUXILIARY CONDENSATE PUMP
12. AUXILIARY BOOSTER PUMP
13. SPRING BEARING
14. AUXILIARY CONDENSER
15. AUXILIARY CIRCULATOR
16. FIRE AND FLUSHING PUMP
17. DIESEL OIL SUPPLY PUMP
18. DIESEL OIL PURIFIER
19. LOW PRESSURE AIR COMPRESSOR
20. LOW PRESSURE AIR ACCUMULATOR
21. #4 BOILER
22. #3 BOILER
23. #2 FUEL OIL BOOSTER PUMP
24. #2 EMERGENCY FEED PUMP
25. #4 FUEL OIL SERVICE PUMP
26. #3 FUEL OIL SERVICE PUMP
27. PORT AND CRUISING FUEL OIL PUMP
28. #3 FIRE AND BILGE PUMP
29. HAND FUEL OIL PUMP

ARRANGEMENT OF MACHINERY
LOWER LEVEL - AFTER PLANT
445 CLASS
FIG 4



1. CONDENSATE COOLER #1
2. EVAPORATING PLANT
3. DISTILLER FRESH WATER PUMP
4. MAIN SWITCHBOARD
5. AUXILIARY AIR EJECTOR
6. MAIN GENERATOR
7. MAIN CIRCULATOR
8. DEAERATING FEED TANK
9. GLAND EXHAUSTER
10. MAIN AIR EJECTOR
11. MAIN GAUGE BOARD
12. LUBRICATING OIL PURIFIER
13. LOW PRESSURE TURBINE
14. HIGH PRESSURE TURBINE
15. CRUISING REDUCTION GEAR
16. CRUISING TURBINE
17. #4 BLOWER
18. FUEL OIL STRAINER
19. FUEL OIL HEATERS
20. #2 BOILER
21. #3 BLOWER
22. #2 BLOWER
23. #1 BOILER
24. #1 BLOWER

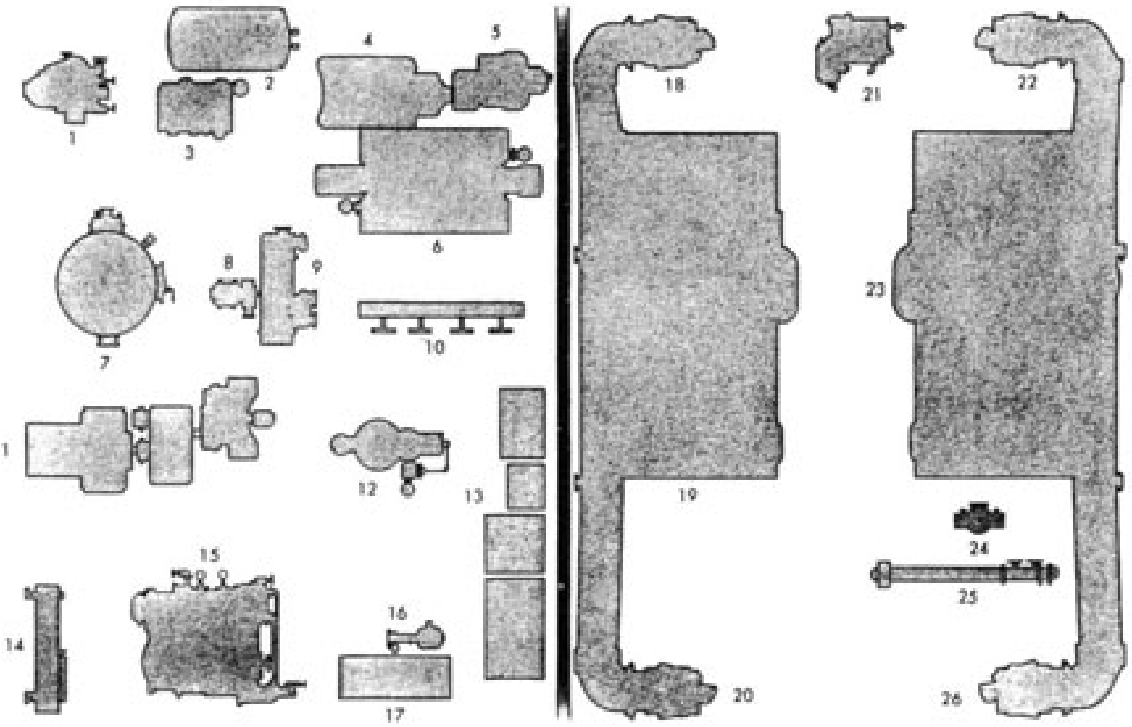
ARRANGEMENT OF MACHINERY
UPPER LEVEL - FORWARD PLANT
692 CLASS
FIG 5



1. DISTILLING CONDENSER CIRCULATING PUMP
2. DISTILLING CONDENSER CONDENSATE PUMP
3. AUXILIARY CONDENSER
4. 1ST EFFECT COIL DRAIN PUMP
5. FRESH WATER PUMP
6. FIRE AND BILGE PUMP
7. EVAPORATOR BRINE PUMP
8. AUXILIARY CONDENSER CONDENSATE PUMP
9. AUXILIARY CONDENSER CIRCULATING PUMP
10. FIRE AND FLUSHING PUMP
11. MAIN FEED PUMP #2
12. MAIN FEED BOOSTER PUMP #2
13. MAIN FEED PUMP #1
14. MAIN CIRCULATING PUMP
15. MAIN FEED BOOSTER PUMP
16. AUXILIARY FEED BOOSTER PUMP
17. MAIN CONDENSATE PUMP #2
18. LUBRICATING OIL SERVICE PUMP 2
19. LUBRICATING OIL SERVICE PUMP #1
20. MAIN CONDENSATE PUMP #1
21. LUBRICATING OIL DISCHARGE STRAINER
22. MAIN REDUCTION GEAR
23. LUBRICATING OIL COCL
24. MAIN CONDENSER
25. FUEL OIL HAND PUMP
26. PORT AND CRUISING
27. FUEL OIL SERVICE PUMP
28. FUEL OIL SERVICE PUMP
29. EMERGENCY FEED PUMP
30. FUEL OIL BOOSTER PUMP
31. FIRE AND BILGE PUMP
32. #2 BOILER
33. #1 BOILER
34. #1 CHAIN DRIVEN LUBRICATING SERVICE PUMP

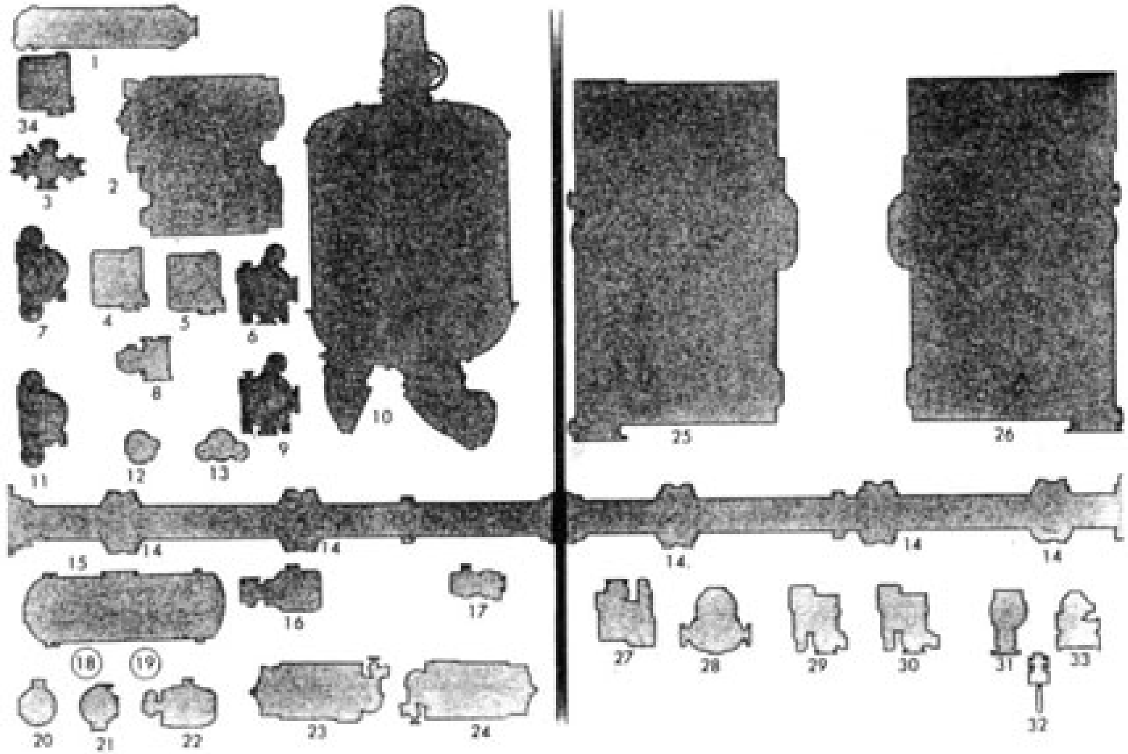
ARRANGEMENT OF MACHINERY
LOWER LEVEL -FORWARD PLANT
692 CLASS

FIG 6



1. LUBRICATING OIL PURIFIER
2. LOW PRESSURE AIR ACCUMULATOR
3. LOW PRESSURE AIR COMPRESSOR
4. HIGH PRESSURE TURBINE
5. CRUISING TURBINE
6. LOW PRESSURE TURBINE
7. DEAERATING FEED TANK
8. GLAND EXHAUSTER
9. MAIN CONDENSER AIR EJECTOR
10. GAUGE BOARD
11. TURBO GENERATOR
12. MAIN CIRCULATOR
13. POWER PANELS
14. AUXILIARY AIR EJECTOR
15. EVAPORATOR
16. DISTILLER F. W. PUMP
17. DISTILLER CONDENSATE TANK
18. #8 BLOWER
19. #4 BOILER
20. #7 BLOWER
21. HIGH PRESSURE AIR COMPRESSOR
22. #6 BLOWER
23. #3 BOILER
24. FUEL OIL STRAINER
25. FUEL OIL HEATERS
26. #5 BLOWER

ARRANGEMENT OF MACHINERY
UPPER LEVEL - AFTER PLANT
692 CLASS
FIG. 7



1. LUBRICATING OIL COOLER
2. MAIN REDUCTION GEAR
3. LUBRICATING OIL DISCHARGE STRAINER
4. LUBRICATING OIL SERVICE PUMP #4
5. LUBRICATING OIL SERVICE PUMP #3
6. STEAM CONDENSATE PUMP #3
7. STEAM BOOSTER PUMP #4
8. FIRE AND BILGE PUMP #4
9. STEAM CONDENSATE PUMP
10. MAIN CONDENSER
11. STEAM BOOSTER PUMP
12. AUXILIARY CONDENSATE PUMP #2
13. AUXILIARY FEED BOOSTER PUMP #2
14. SPRING BEARING
15. AUXILIARY CONDENSER
16. AUXILIARY CONDENSER CIRCULATING PUMP
17. FRESH WATER PUMP #2
18. DISTILLER CONDENSATE PUMP
19. DISTILLER CONDENSER CIRCULATING PUMP
20. EVAPORATOR BRINE PUMP
21. 1ST EFFECT COIL DRAIN PUMP #2
22. FIRE AND FLUSHING PUMP #2
23. MAIN FEED PUMP #4
24. MAIN FEED PUMP #3
25. #4 BOILER
26. #3 BOILER
27. #2 FUEL OIL BOOSTER PUMP
28. #2 EMERGENCY FEED PUMP
29. #4 FUEL OIL SERVICE PUMP
30. #3 FUEL OIL SERVICE PUMP
31. PORT AND CRUISING FUEL OIL PUMP
32. HAND FUEL OIL PUMP
33. #3 FIRE AND BILGE PUMP
34. #2 CHAIN DRIVEN LUBRICATING OIL SERVICE PUMP

ARRANGEMENT OF MACHINERY
LOWER LEVEL - AFTER PLANT
692 CLASS
FIG 8

Section III

STEAM CYCLE OF THE PRESSURE CLOSED FEED SYSTEM

1. GENERAL DISCUSSION

With the continued increase in the strength and heat resisting qualities of steel, made possible by the development of alloy steels, came a corresponding increase in pressures and temperatures available for use in steam power plants. This increase allowed for greater power and higher efficiency of marine propulsion units. However, these increases carried with them correspondingly higher temperatures in the boilers or steam generating units of these plants. As the temperature in the boiler increases, the presence of any oxygen, entrained or absorbed in the feed water, becomes, in direct proportion to the temperature, the cause of rapid corrosion. Wherever water is exposed to the air, oxygen will be absorbed by the water and, if not removed, will be carried into the boiler. The necessity, then, for keeping the feed water from coming into contact with air caused the development of the closed feed system.

2. TYPES OF CLOSED FEED SYSTEMS

(a) General.-There are several types of closed feed systems in general use. All of these are basically the same except for the method of removing oxygen and air from the condensate, and the range of steam pressures and temperatures are used. The boiler corrosion problem here is not sufficiently great to require the removal of all oxygen and air from the feed water, but the continued absorption of air obtained with the open feed system must be prevented. To prevent this, a completely closed feed tank is used, the top of which is vented to the main condenser to prevent the presence of air in contact with the surface of water in the tank. The presence of this vacuum will also have the effect of aiding in the partial removal of air from the water.

(d) Pressure Closed Feed System.-With a normal operating pressure in the boiler of 615 p.s.i. and the consequently high temperature in the boiler tubes, it is necessary to accomplish the removal of all oxygen and air from the feed water before it is delivered into the boiler. To accomplish this purpose the pressure closed feed system is employed. Here the feed tank is also entirely enclosed. The tank is placed under a pressure of steam and incorporates, also, a device for mixing steam and water to accomplish scrubbing of the water and freeing of all entrained and absorbed air and oxygen from the water. This system is the system employed in the main propulsion plants of all DD445 and DD692 class destroyers.

3. OPERATION OF THE PRESSURE CLOSED FEED SYSTEM

Figure 9 is a diagrammatic representation of the pressure closed feed system. In this system water and steam circulate throughout the entire cycle of operation without ever being exposed to the atmosphere. This cycle, being continuous and completely enclosed, will allow us to follow the flow of water and steam, discuss it at any point, and trace the return to the starting point. For the purpose of this text, it is considered desirable to start with the water as it rests in the main condenser in the form of condensate. In the main condenser, steam has just been converted into water (condensate) and is ready to be prepared for use as feed water. To remove the condensate from

degree to which it must be removed. The amount of oxygen which must be removed is proportional to the temperatures employed in the boiler and, since these temperatures are proportional to the steam pressure, the higher the pressure used the more oxygen must be removed.

(b) Semi-enclosed Feed System.-The semi-enclosed feed system is used for the lower steam pressures and temperatures. The major difference between this system and the systems later described is that an open feed tank is utilized. Since the lower temperatures involved do not require the removal of much oxygen, the oxygen absorbed in this open feed tank does not have as harmful an effect on the boiler.

(c) Vacuum Closed Feed System.-The vacuum closed feed system is used where the middle

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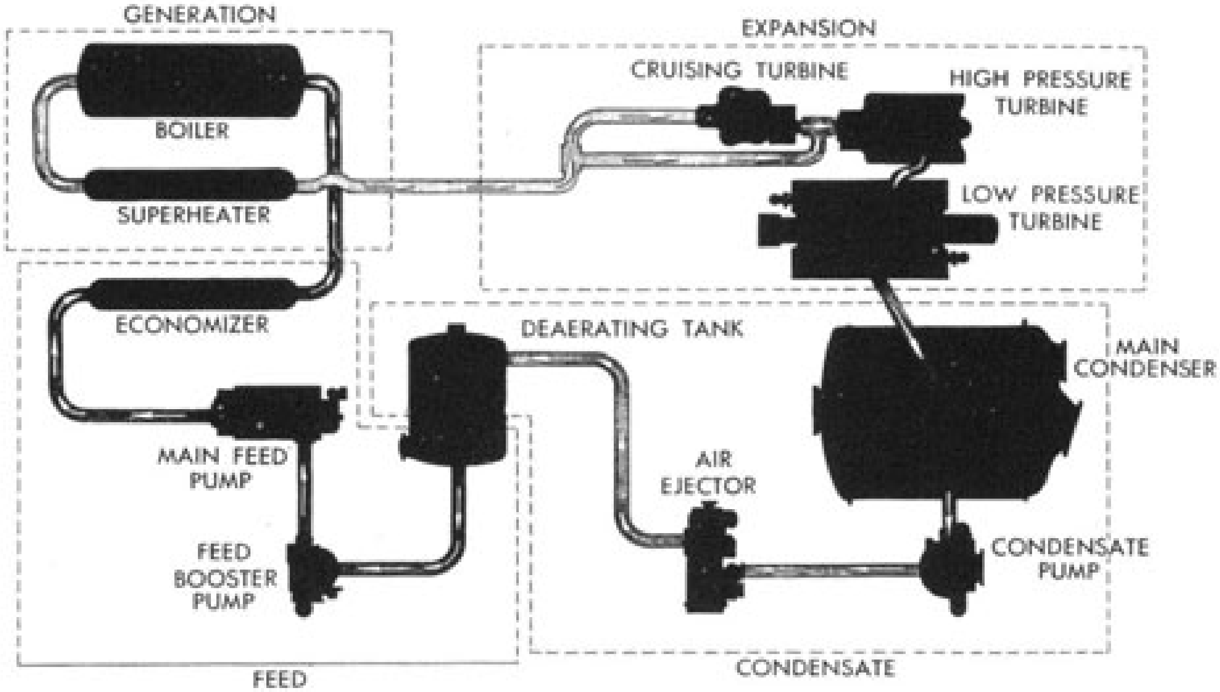
the main condenser the condensate pump is used. This condensate pump discharges the condensate through an air ejector where it serves as cooling water in the condensers of the air ejector. From here it passes into the deaerating feed tank. In this tank the water is so treated that all the entrained and absorbed oxygen and air are removed and the water is heated preparatory to pumping it to the boilers as feed water. In this condition it can now be called feed water. The feed water is removed from the deaerating feed tank by the main feed

economizer where the water is further heated and finally into the boiler. Circulating through the boiler, the water is heated by heat from the furnace and steam is formed. The steam is then directed through a superheater where its temperature is raised to a point as far above its saturated temperature as desired. It is then directed into the turbines where it is expanded and its heat transformed into the mechanical energy of rotation. All the heat possible having been removed from the steam, and it having been expanded to a vacuum of approximately 29 inches, it is exhausted into the main condenser, where it is condensed back into condensate.

booster pump and discharged under pressure to the main feed pump, which further raises the pressure, and discharges it through an



THE STEAM CYCLE
FIG. 9

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Section III

STEAM CYCLE OF THE PRESSURE CLOSED FEED SYSTEM

1. GENERAL DISCUSSION

With the continued increase in the strength and heat resisting qualities of steel, made possible by the development of alloy steels, came a corresponding increase in pressures and temperatures available for use in steam power plants. This increase allowed for greater power and higher efficiency of marine propulsion units. However, these increases carried with them correspondingly higher temperatures in the boilers or steam generating units of these plants. As the temperature in the boiler increases, the presence of any oxygen, entrained or absorbed in the feed water, becomes, in direct proportion to the temperature, the cause of rapid corrosion. Wherever water is exposed to the air, oxygen will be absorbed by the water and, if not removed, will be carried into the boiler. The necessity, then, for keeping the feed water from coming into contact with air caused the development of the closed feed system.

2. TYPES OF CLOSED FEED SYSTEMS

(a) General.-There are several types of closed feed systems in general use. All of these are basically the same except for the method of removing oxygen and air from the condensate, and the degree to which it must be removed. The amount of oxygen which must be removed is proportional to the temperatures employed in the boiler and, since these temperatures are proportional to the steam pressure, the higher the pressure used the more oxygen must be removed.

(b) Semi-enclosed Feed System.-The semi-enclosed feed system is used for the lower steam pressures and temperatures. The major difference range of steam pressures and temperatures are used. The boiler corrosion problem here is not sufficiently great to require the removal of all oxygen and air from the feed water, but the continued absorption of air obtained with the open feed system must be prevented. To prevent this, a completely closed feed tank is used, the top of which is vented to the main condenser to prevent the presence of air in contact with the surface of water in the tank. The presence of this vacuum will also have the effect of aiding in the partial removal of air from the water.

(d) Pressure Closed Feed System.-With a normal operating pressure in the boiler of 615 p.s.i. and the consequently high temperature in the boiler tubes, it is necessary to accomplish the removal of all oxygen and air from the feed water before it is delivered into the boiler. To accomplish this purpose the pressure closed feed system is employed. Here the feed tank is also entirely enclosed. The tank is placed under a pressure of steam and incorporates, also, a device for mixing steam and water to accomplish scrubbing of the water and freeing of all entrained and absorbed air and oxygen from the water. This system is the system employed in the main propulsion plants of all DD445 and DD692 class destroyers.

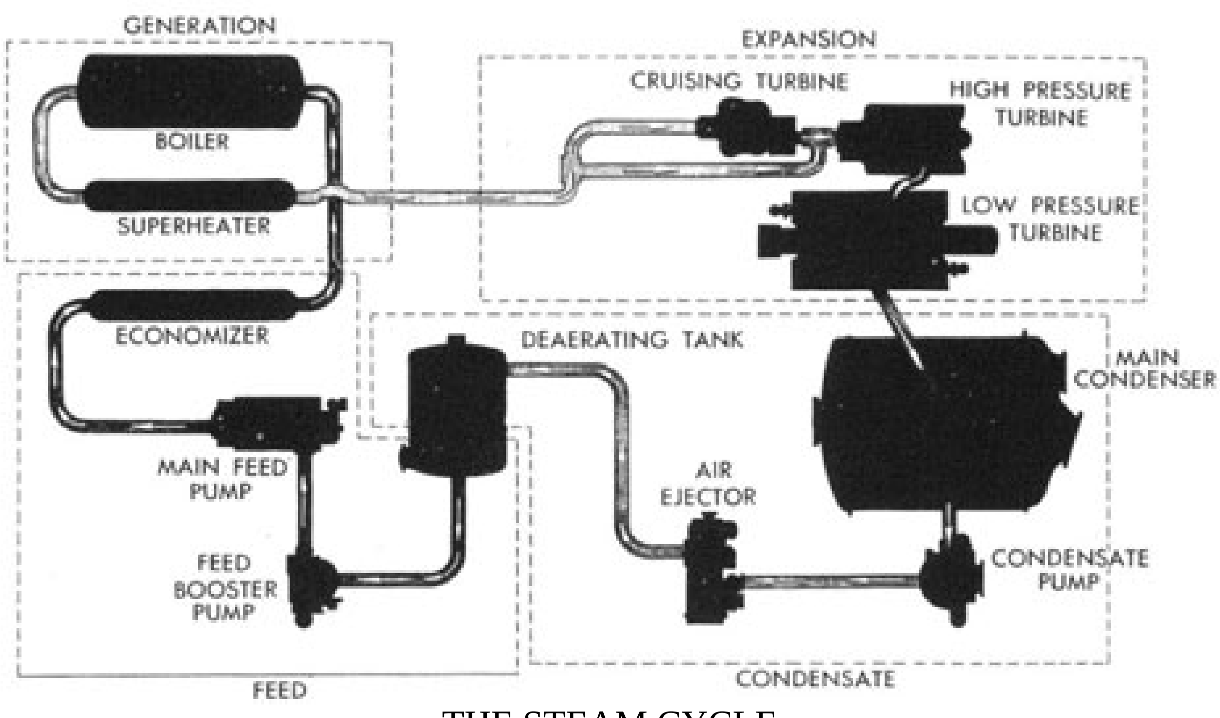
3. OPERATION OF THE PRESSURE CLOSED FEED SYSTEM

Figure 9 is a diagrammatic representation of the pressure closed feed system. In this system water and steam circulate throughout the entire cycle of operation without ever being exposed to the atmosphere. This cycle, being continuous and completely enclosed, will allow us to follow the flow of water and steam, discuss it at any point, and trace the return to the starting point. For the purpose

between this system and the systems later described is that an open feed tank is utilized. Since the lower temperatures involved do not require the removal of much oxygen, the oxygen absorbed in this open feed tank does not have as harmful an effect on the boiler.

(c) Vacuum Closed Feed System.-The vacuum closed feed system is used where the middle of this text, it is considered desirable to start with the water as it rests in the main condenser in the form of condensate. In the main condenser, steam has just been converted into water (condensate) and is ready to be prepared for use as feed water. To remove the condensate from

the main condenser the condensate pump is used. This condensate pump discharges the condensate through an air ejector where it serves as cooling water in the condensers of the air ejector. From here it passes into the deaerating feed tank. In this tank the water is so treated that all the entrained and absorbed oxygen and air are removed and the water is heated preparatory to pumping it to the boilers as feed water. In this condition it can now be called feed water. The feed water is removed from the deaerating feed tank by the main feed booster pump and discharged under pressure to the main feed pump, which further raises the pressure, and discharges it through an economizer where the water is further heated and finally into the boiler. Circulating through the boiler, the water is heated by heat from the furnace and steam is formed. The steam is then directed through a superheater where its temperature is raised to a point as far above its saturated temperature as desired. It is then directed into the turbines where it is expanded and its heat transformed into the mechanical energy of rotation. All the heat possible having been removed from the steam, and it having been expanded to a vacuum of approximately 29 inches, it is exhausted into the main condenser, where it is condensed back into condensate.



THE STEAM CYCLE

FIG. 9

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Section IV

CONDENSATE SYSTEM

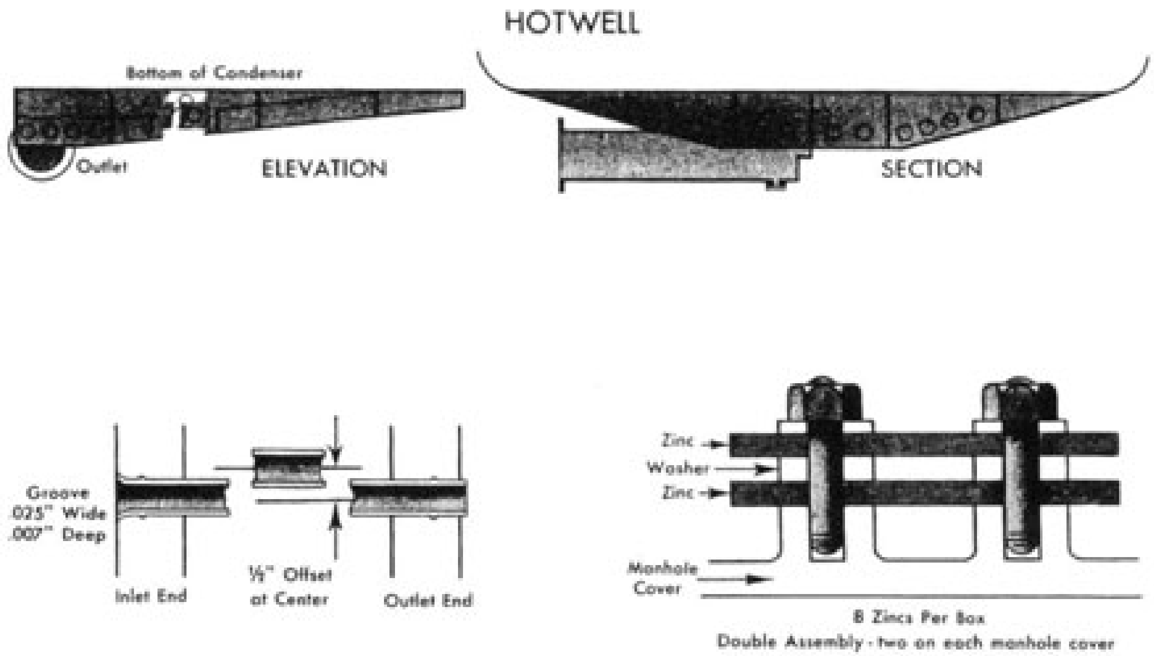
1. GENERAL DISCUSSION

(a) Description.-The condensate system is that part of the steam cycle in which water flows from the main condenser toward the boilers while it is being prepared for use as feed water. The several elements of this system are: the main condenser in which steam is condensed and collected as condensate; the main condensate pump which removes condensate from the main condenser; the main air ejector, through which condensate is passed to serve as cooling water, and which has the function of removing air from the main condenser; and the deaerating tank. which finally prepares condensate for use as feed water. Piping connects all these elements. thereby requiring that each element operate in perfect coordination with each other element in order that proper operation of the system, as a whole. may be maintained. As in all other systems, hereinafter discussed, we will first describe the action within each element and thereafter show by description of the piping how all these elements are connected together into a single system.

(b) Notes on Vacuum.-In all ocean-going marine power plants a condenser is employed to convert the steam exhausted from the main engines back into water so that it can be returned to the boiler as feed water. In these condensers a vacuum is maintained at as high a level as possible in order to obtain maximum economy and maximum power. In a strict sense, the vacuum in the condenser is not a vacuum. All gages indicate pressures which start with zero at atmospheric pressure. Therefore, we use the term "vacuum" to indicate that the pressure is less than atmospheric. The average atmospheric pressure at sea level is 14.7 p.s.i. If we have a pressure which is 4.7 p.s.i. above it will he held up by the atmospheric pressure (14.7 p.s.i.) to a height of 30 inches, where the weight of the column of mercury becomes equal to the 14.7 p.s.i. of atmospheric pressure. If an absolute pressure greater than 0 p.s.i. exists above the mercury, the height of the column will be reduced by approximately 2 inches for each 1 p.s.i. of pressure. Thus, when we say there is 28 inches of vacuum, there is actually 1 p.s.i. of absolute pressure. Atmospheric pressure is, however, variable. With a constant absolute pressure in the condenser, variations in atmospheric pressure will create corresponding variations in the amount of vacuum shown on a gage. Therefore, a change in vacuum gage reading may not necessarily indicate a change in condition of the condenser but may merely reflect a change in atmospheric pressure. Checking the absolute pressure gage or the barometric height will indicate whether such is the case.

(c) Condenser Temperatures.-Under normal operation the condenser will he filled with steam under the absolute pressure existing in the condenser. A definite relation exists between the pressure of saturated steam and its temperature. An absolute pressure of 1 p.s.i. will give a corresponding gage reading in vacuum of approximately 28" of mercury. The temperature of saturated steam at 1 p.s.i. absolute pressure will be 101.2 degrees F. If some external condition causes the condenser temperature to remain hotter than this, or if the cooling water temperature is not held below this, the steam will not be condensed and the absolute pressure in the condenser will rise, reducing the vacuum shown on the gage. It is apparent that the greater the vacuum obtained, the lower will be the temperature of the steam. The lower the temperature of the steam in the condenser,

less than atmospheric the gage will indicate a vacuum, but there will be 10 p.s.i. of pressure remaining. This pressure is referred to as "absolute" pressure to differentiate it from "gage" pressure (above atmospheric). These absolute pressures are generally referred to as "vacuum" in inches of mercury. A column of mercury with 0 p. s.i. absolute pressure the more heat we have available for conversion into mechanical energy in the engines. For maximum power, then, the vacuum should be carried at as high a level as possible. In doing this, care should be exercised to see that. the temperature of the condensate and of the cooling water discharged is not reduced



MAIN CONDENSER DETAIL
FIG. 10

materially below that of the condenser temperature (temperature corresponding to existing vacuum). This condition might cause a reduction in feed temperature which could well reduce the capacity of the boilers to the extent that the over-all power is reduced. To maintain maximum economy of operation the temperature of the circulating water discharge should be maintained 5 degrees to 8 F. below the temperature of the existing vacuum. This will allow for maximum vacuum consistent with an economical temperature of the condensate. It will, in many cases, be necessary to reduce the amount of cooling water to obtain this effect.

2. MAIN CONDENSER

(a) General Description.-The main condenser installed in all DD445 and DD692 class destroyers, is a single-pass condenser containing 6,404 tubes, with a cooling surface of 11,000 square feet. The overall length of these tubes is 10 feet 8 5/8 inches. Their outside diameter is 5/8 inches with a wall thickness of 0.049 inch. Circulating water from the sea flows through these tubes to provide the cooling medium necessary for condensation of the steam discharged into the condenser. This water is furnished either by means of a main circulating pump or through a scoop

This can be done by reducing the speed of the main circulating pump (but not so low that it may stop). In case the flow of water must be reduced to the extent that the tubes will not all be filled, the overboard discharge valve may also be choked down but should never be closed more than three-quarters. On ships employing reciprocating circulating pumps (not the case in these ships) the overboard discharge valve should never be choked with the pump in operation.

connection. The scoop connection can be used to supply sufficient water to the main condenser for all speeds during ahead operation above 6 knots. At speeds less than 6 knots and during astern operation the main circulating pump must be operated.

(b) Tubes.-The tubes used in this condenser are made of copper-nickel alloy. No ferrules are used in either tube sheet, the tubes being expanded into both inlet and outlet sheets. Those at the inlet sheet are belied to provide for fair entry of the

water and are cut off flush with the tube sheet. At the outlet tube sheet, the tubes are not belied and are allowed to extend about one-eighth inch beyond the sheet. Grooves (fig. 10) are cut around the hole in each tube sheet to allow for positive sealing of the tube. As the tubes are rolled, metal from them is pressed into these grooves. The grooves are 0.007 inch deep and 0.025 inch wide. To provide for expansion of the tubes and to allow for easy drainage of all water from the tubes, they are installed with a bow which allows the tube to rise one-half inch in the center of the condenser. After a preliminary operating period plastic ferrules are installed at the inlet end of each tube for the purpose of preventing the rapid erosion encountered due to the velocity of water entering the tube. This is done after this preliminary period to allow for the correction of any leaks discovered during the preliminary operation. The tube sheets into which these tubes are rolled are made of a solid sheet of copper-nickel alloy.

(e) Baffling.-The condenser is divided, by baffling, into four air cooler sections through which all air to be exhausted from the condenser must pass and which are connected, by pipes, to the air suction connection at the top of the

destruction of the metallic elements of the condenser. It has been found that the presence of zinc in the water boxes will prevent destruction of this metal, while the zinc itself will be eaten away. The zincs can be readily replaced, while the condenser cannot. Therefore, in order to prevent the eventual destruction of the condenser, several zincs are placed in each water box. These zincs are attached, in assemblies, on each of the manhole plates in the headers. Two zincs are mounted in each assembly, as shown in figure 10, separated from one another by spacers three-fourths inch thick and secured to the manhole cover by studs. They must make a good contact with the metal of the manhole cover. Two of these assemblies are mounted on each manhole plate, providing 8 zincs in each water box, or 16 in all.

(f) General Notes.-There are two relief valves installed on each condenser, one on the salt water side which is adjusted to lift at 20 p.s.i., and one on the fresh water side which is adjusted to lift at 5 p.s.i. After installation but before being put into operation, the fresh water side of each condenser is tested under 10 p. s.i. hydrostatic pressure. and the salt water side is tested under 13.5 p.s.i. hydrostatic pressure. From the inlet water box of the main condenser, salt water is led into the lubricating oil cooler to furnish cooling water for that unit.

condenser. The lower portion of the condenser is baffled lengthwise to prevent surging of condensate from one end to the other. Sealing plates are welded to the bottom of the condenser throughout its length to prevent the free flow of steam into the air coolers. A condensate collecting tray is installed below each group of condenser tubes and is formed by longitudinal baffle plates welded to the bottom of the condenser. These plates have serrated top edges and are divided into small compartments by transverse baffles. This allows a steady flow of water into the hot well while maintaining a seal of 3 inches of water in each compartment unless the ship lists more than 15 degrees .

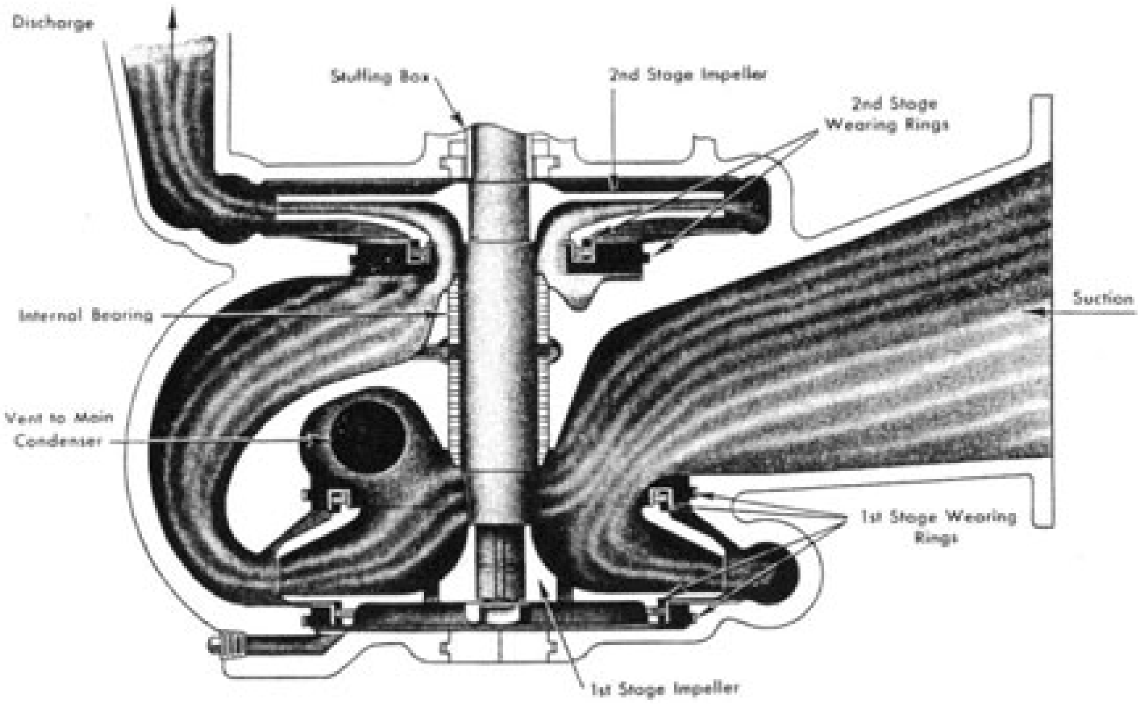
(d) Hot-Well.-The hot-well is built up of welded plates on the base of the condenser. This is made up of flat plates all of which slope toward the condensate outlet. The hot-well is also baffled in both directions in a manner which will prevent surging of water but still allow free flow to the condensate outlet connection. Figure 10 illustrates this method of baffling.

(e) Zinc Plates.-The presence of salt water in the inlet and outlet water boxes will cause electrolytic action to be set up which may cause the

3. MAIN CONDENSATE PUMPS

(a) General Discussion.-As noted in the discussion of the steam cycle, condensate is removed from the hot-well of the main condenser by means of a condensate pump. Two condensate pumps are installed in each engineroom, both of which are capable of taking suction from the hot-well of the main condenser. Both of these pumps are vertical two-stage centrifugal pumps. The DD445 class destroyers have one electrically driven condensate pump installed, in which both pump and motor operate at a speed of approximately 1,150 r.p.m., and one turbine driven pump with the steam turbine connected to the pump end through a worm and wheel reduction gear. The turbine speed will vary slightly with the make of turbine but in general will be about 5.300 r.p.m., while the pump operates at approximately 1,150 r.p.m. The DD692 class has two turbine-driven main condensate pumps.

(b) Operation.-An examination of figure 11 will show the suction connection arranged to lead



MAIN CONDENSATE PUMP - PUMP END
Fig. 11

Water from the hot-well down into the 1st stage impeller where it flows through the entrance. ports around the pump shaft. The speed of rotation of the impeller imparts centrifugal force to this water, and by this centrifugal action the water is thrown from the impeller into the discharge casing of the first stage, under pressure.

A connecting pipe, built into the pump casing leads from the first stage discharge casing up to the second stage suction. As the sketch shows, water enters the second stage from below the impeller, passing through the inlet ports, also around the shaft, and is discharged under pressure from the second stage impeller, through the same centrifugal action as in the first stage. From the second stage casing, the condensate, under pressure, is led off into the condensate piping system.

(c) Wearing Rings.-Since the impellers of this pump must rotate and the casing remain stationary, it is essential that a clearance be maintained between the impeller and casing. The for water from the discharge casing of either stage to leak back into the suction side of the impeller and thereby lower the discharge pressure and reduce the capacity of the pump. In order to prevent this, the clearance must be made as small as possible to allow a minimum of water to pass. For a new installation about 0.008 inch is considered proper clearance. Were the impeller and casing machined to this clearance, the rapid rush of water, however small, through the space, would cause wear which would gradually increase this clearance. Eventually the clearance would become sufficiently great to materially reduce the capacity of the pump and then it would be necessary to restore the clearance to its original figure. This would mean renewal of the impeller. In order to allow us to restore this clearance, whenever necessary, without renewing the impeller, removable rings, manufactured of gun metal or a similar material, are installed on both impeller and casing. Normal wear will now occur on these rings and not on the impeller or the casing. When the clearance becomes too great it is then

presence of this clearance would make it possible

only necessary to renew the removable rings in order to restore the clearance. These rings are called wearing rings, and spares are provided so that when the clearance between the impeller and casing wearing rings exceeds 0.030 inch they can he renewed to restore the clearance to its original design of approximately 0.008 inch. As will be noted in figure 11, in the main condensate pump there are three sets of wearing rings, one set at the side of the first stage impeller, providing a seal between first stage suction and discharge; the second set, made necessary by the equalizing holes through the impeller, installed at the base of the first stage impeller; and the third set at the side of the second stage impeller, providing a seal between the second stage suction and discharge. Due to the small clearance between the wearing rings any undue heating of the pump will cause an expansion of the rings and eventual contact between the impeller rings and casing rings. This will, of course, seize the pump. Overheating of these pumps may be the result of several things, but basically they all stem from one condition, that is, the lack of circulation of water, through the pump, to carry away the heat built up by the speed of rotation. If, for instance, the discharge line from the pump is closed off, the impellers will rotate in stationary water. The heat built up due to this rotation will remain in the pump, since water is not flowing through it to carry this heat away. This will eventually cause heat to build up to such an extent that the wearing rings expand and seize. If vapor is allowed to enter the impeller, this vapor, having little weight, will not be affected by the centrifugal action of the impeller and will remain in the impeller, preventing water from flowing to it and destroying water circulation through the pump. Precautions may be taken to prevent any of the above occurrences. In the first place, the discharge line from the pump must be must always be in operation. To provide against the pump becoming vapor bound a vent connection is supplied on the suction casing of the first stage. This connection leads back to the main condenser and any vapor which may enter or flash in the first stage suction casing will, if this connection is open, be vented back into the maul condenser before entering into the impeller. This means then that the vent connection from the first stage must be always open whenever the pump is in operation. In this connection, it should be noted that, when securing one pump and starting the other the vent on the pump to be secured must be closed to prevent destruction of the vacuum in the main condenser. This is noted here because it has in the past been a common casualty causing reduction of main condenser vacuum.

(d) Lubricating System.-The steam pump has a self-contained lubricating system, the sump of which is the reduction gear case. An attached lubricating oil pump delivers oil to all parts of the system through a lubricating oil cooler. The lubricating oil cooler is serviced with salt water, for cooling, from the salt water service system of the ship. Pressure in the lubricating oil system is held down to about 8 p.s.i. by a relief valve which discharges into the sump tank. The oil now recommended for use in these wormwheel reduction gear systems is Navy Symbol 3080. In connection with the lubricating system it should be noted that the pump should not be brought up to full speed until the temperature of the oil flowing to the bearings is at least up to 90 degrees F.. and that a good running temperature for oil entering the bearings is between 120 degrees and 130 degrees F.

(e) Turbine Control.-The speed of the turbine of the steam pump is controlled only by a limit speed

open so that the flow of water can be maintained from the pump at all times. This means that the piping of the condensate system must be fully lined up before starting the main condensate pump. In the case of the second possible occurrence, a recirculating system is installed which provides for recirculation of water to the hotwell of the main condenser for use whenever insufficient water is entering the condenser to provide suction to the main condensate pump. This means that when warming up and securing the main plant, the recirculating system

governor. The function of this governor is to reduce the steam flowing to the turbine when the turbine speed approaches its maximum allowable r.p.m. so that the turbines will never exceed this maximum allowable r.p.m. This is accomplished by a centrifugal weight governor which acts through a rocker arm to vary the opening of a piston valve which consequently varies the steam delivered to the pump turbine. Adjustment of the speed to which the turbine will be limited call be made by removing the cover from the governor assembly and changing the tension of the spring which works against the weights. The total travel from fully closed to fully open of the governor valve should be adjusted to be one

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fourth inch, and this travel adjustment should be checked alter each readjustment of the spring. The pump is normally operated with the throttle valve wide open, passing full steam pressure to the governor valve and thereby allowing the governor valve to control the speed of the pump at its limit speed. Then, as the load on the pump increases power will always be available to meet it. An increase in load will cause the pump to slow down and this will cause the governor valve to open wider, increasing the steam delivered to the turbine. This has a tendency to require the governor valve to act as a constant speed governor, a function for which it is not designed, but, while the speed of the pump may vary somewhat with the change in load, the variation will not be sufficiently great to cause any unsatisfactory functioning of the unit.

4. MAIN AIR EJECTOR

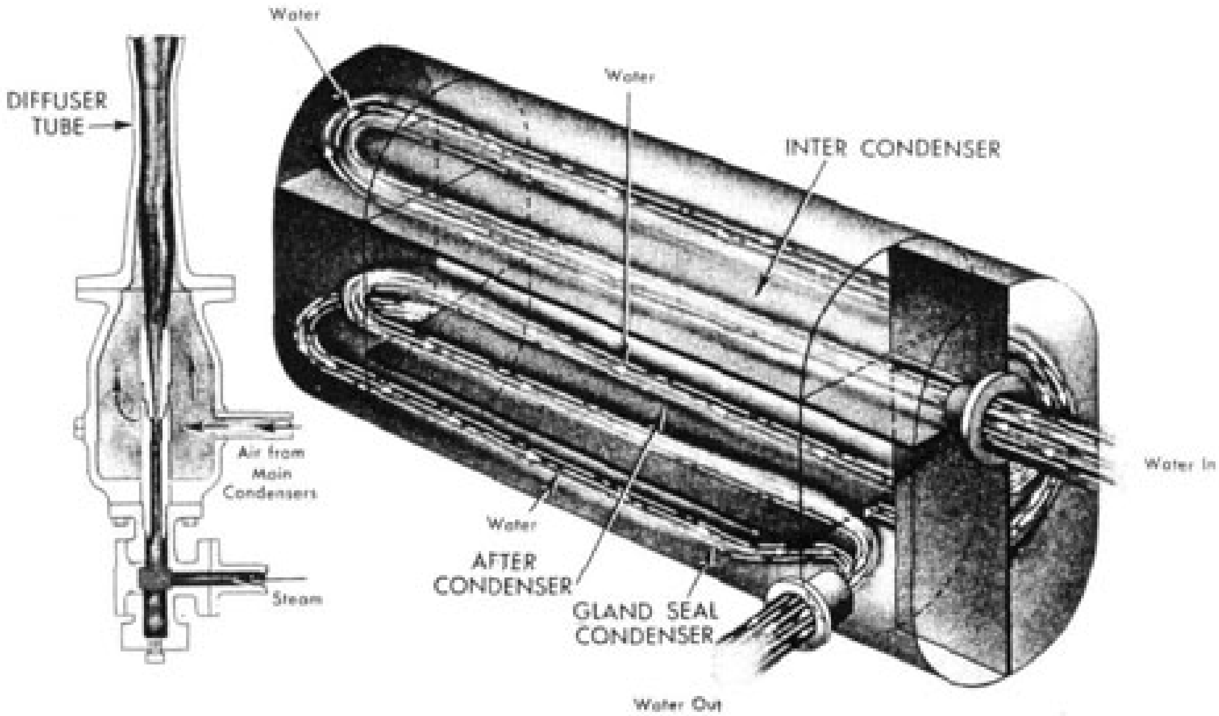
(a) General Discussion.-The main air ejector installed in both DD445 class and DD692 class destroyers is a two-stage condensing air ejector. The condensate which has been discharged from

The air suction chamber is piped directly to the suction connection of the main condenser or, in the case of the second stage, to the inter-condenser. The action of the nozzle is as follows: steam passes through the nozzle, is expanded and its velocity greatly increased. This high velocity causes an evacuation of the air suction chamber forming a vacuum within the chamber. This vacuum being in direct connection with the main condenser causes the liberated air and any uncondensed vapors in the main condenser to flow into the air suction chamber, from where it is continually withdrawn by the action of the nozzle. This necessitates that there always be in the air suction chamber a slightly higher vacuum than in the main condenser, perhaps 0.2 inch. The steam from the nozzle mixes with the air, just drawn from the main condenser, in the diffuser tube, and from there passes into the air ejector condenser. This diffuser tube is an essential part of the nozzle, since without it we would be unable to maintain much difference between the vacuum in the condenser on the discharge side of the nozzle and that on the suction side of the nozzle. The slight restriction in this diffuser tube causes the pressure to build up to a slightly higher level than that in the condenser on the discharge side. This forms a seal between the air

the main condensate pump passes through the condensers of this air ejector to act only as cooling water in these condensers. The function of the air ejector is to remove from the main condenser all air liberated in that condenser, consequently maintaining a high level of vacuum. There are two sets of air-ejection nozzles attached to the air ejector, and the shell consists of three condensers banked one over the other. These three condensers are, in order from top to bottom, the inter-condenser, the after-condenser and the gland steam condenser. Only the inter- and after-condensers are a part of the air ejector, the gland steam condenser being included here only for convenience. Condensate from the main condensate pump enters first the inter-condenser and, making two passes, enters the after- and gland-steam- condensers simultaneously, its flow dividing. Two passes are made in each of these condensers, and the flow again joins and discharges into the condensate line and finally to the deaerating feed tank.

(b) Operation.-Each air ejector nozzle consists of a steam nozzle, air suction chamber, and a diffuser tube. As shown in figure 12, the steam nozzle is installed in the center of the air suction chamber and discharges into the diffuser tube which is flanged to the air ejector condenser.

suction chamber and the condenser and prevents equalization of vacuum between the two, while at the same time providing for continuous flow of steam into the condenser. As previously mentioned, this is a two-stage air ejector, which means that there are two sets of nozzles. The first-stage nozzle takes suction from the main condenser and discharges into the inter-condenser of the air ejector. Here the steam is condensed, and the air removed from the main condenser is liberated into the inter-condenser shell. This air could be exhausted to the atmosphere were this a single-stage air ejector, but since this would allow the possibility of a. direct connection between the atmosphere and the main condenser, the second stage is introduced. Introduction of this second stage not only prevents this possible connection but also greatly increases the efficiency of the first stage. The second stage nozzle obtains its suction from the shell of the inter-condenser and discharges into the after-condenser. The steam from this nozzle is condensed here, and the air liberated into the after-condenser shell, from where it is removed by the gland exhauster. The gland exhauster is installed



MAIN AIR EJECTOR
Fig. 12

mainly to draw vapor from the gland seal condenser but, since it is in such close proximity to the after-condenser, it can be used to remove the air with little difficulty. The combined steam, vapor and air in the inter-condenser is forced by baffles to go through three passes before being picked up by the second-stage nozzle. Condensate formed in the inter-condenser is returned to the main condenser through the loop seal. The steam, vapor and air in the after condenser are forced by baffles through two passes, and the condensate returned to the low pressure drain system by gravity. A discussion of the loop seal through which the inter-condenser drains are returned to the main condenser is included in the next paragraph.

(c) Notes on Operation.-The capacity of underway, the first-stage nozzle should be placed in operation, forming full vacuum in the main condenser. When shifting nozzles while underway, it is necessary, with this installation, to shift the nozzles of both stages. To do this, the new nozzles must be warmed up and placed in operation before opening their air suction valves. If this is not done the inter- and after-condensers will be equalized in vacuum and the inter-condenser will he equalized, through the first stage, with the main condenser. With the nozzles in operation, however, before opening the suction valves, a vacuum will be formed in each air suction chamber before the cross connection is made. For a moment then, both sets of nozzles will be in operation. The set to be secured should have the air suction valves closed before securing steam to the nozzles.

5. LOOP SEAL

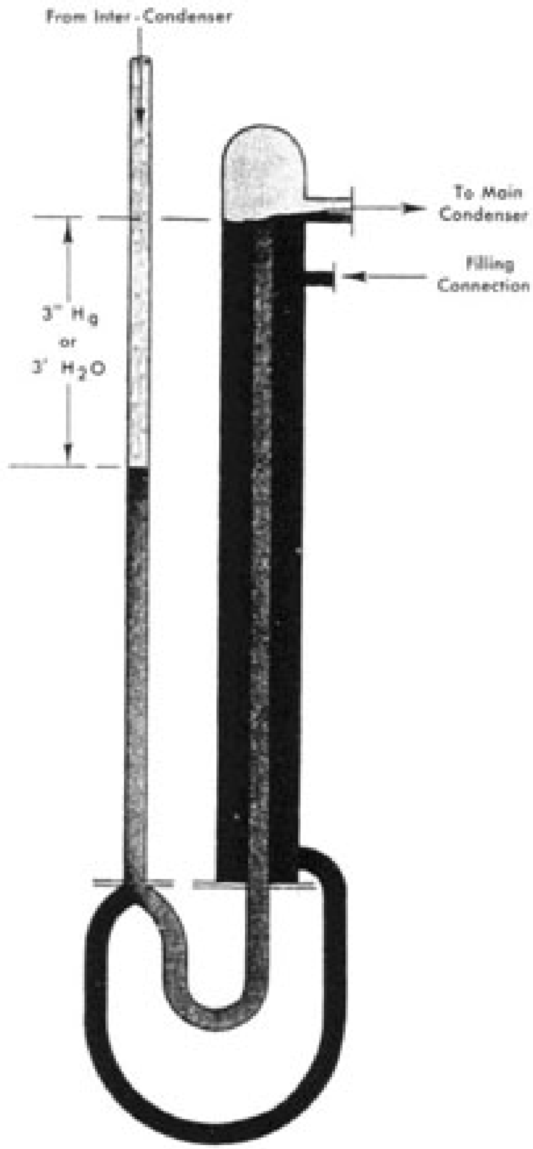
(a) General Discussion.-As noted in the text on the main air ejector, the condensate formed in the inter-condenser is returned to the main condenser through the loop seal. Were a direct connection between the inter-condenser and the main

the nozzles of this air ejector is sufficient so that under all conditions of normal operation, including full power, one nozzle for each stage is sufficient. If a great amount of air is leaking into the condenser it may be necessary to use two nozzles for each stage in order to maintain much vacuum. However, when this condition occurs, you cannot expect to have as much vacuum as normally, since the increased temperature in the air ejector will cause a reduction in the possible vacuum. The steam pressure required by these nozzles is 275 p.s.i. This pressure is sufficient for capacity operation and if carried lower than 275 p. s.i. will not provide full vacuum for the main condenser. If carried much higher than 275 p.s.i. a reduction in the vacuum can be expected, due to overheating of the air ejector. To place the air ejector in operation, first insure that condensate is circulating through the air ejector condensers, then place the second-stage nozzle in operation, first opening the valves at the discharge and air suction connections of the first-stage nozzle. This will allow the second-stage nozzle to form a vacuum in the inter-condenser and, through the first-stage nozzle, in the main condenser. It is not desirable to admit steam to the first-stage nozzle until there is at least 16 inches of vacuum in the inter-condenser. With these installations, however, it is possible for the second-stage nozzle alone to draw 26 1/2 inches of vacuum on the main condenser. This is sufficient vacuum for all purposes until steam is to be admitted to the main condenser from the main turbines. Before the main turbines are to be turned over with steam preparatory to getting

condenser used to return this condensate, the vacuum would be equalized in the two condensers. Since the main condenser is capable of carrying a higher vacuum than that in the inter-condenser, it is necessary that some form of seal be maintained in this drain line to prevent this equalization of vacuum. To provide this seal, the loop seal is installed in the drain connection.

(b) Operation.-Figure 13 is a diagrammatic representation of the loop seal. Water from the inter-condenser passes down through the small one-inch pipe, then through the short loop and up through the internal pipe shown. The larger pipe surrounding the internal pipe is 3 inches and is connected, as shown, to the main condenser. Water overflowing the internal pipe fills the external pipe and the larger loop. Before vacuum is formed in either condenser water from the inter-condenser would flow through the 1-inch pipe and overflow into the main condenser. This would mean that the water level in the primary leg of the 1-inch pipe would stand at the same height as the connection from the external pipe to the main condenser. When vacuum is formed in both condensers, there would be, under normal operation, a difference between the vacuum held on the main condenser and that on the inter-condenser

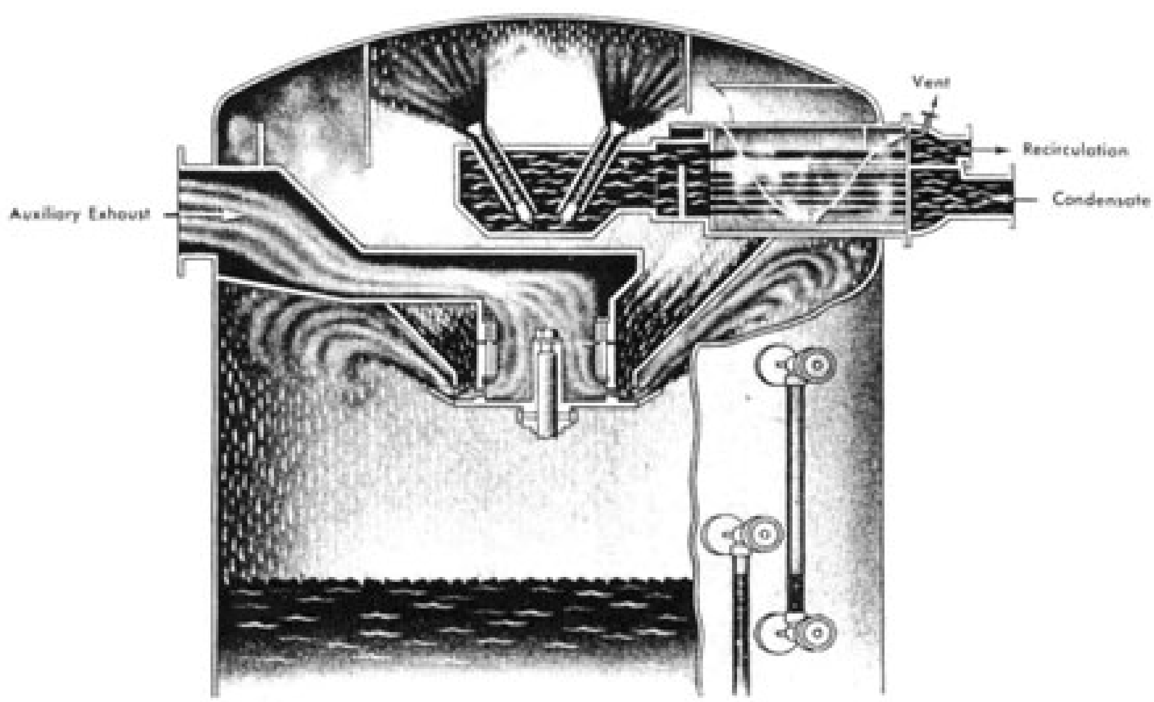
of about 3 inches, that is, with about 29 inches on the main condenser, there will be about 26 inches on the inter-condenser. If we reduce this vacuum to absolute pressure, we will have 1/2 p.s.i. of absolute pressure working down on the internal and external pipes and 2 p.s.i. of absolute pressure working down against the water level in the primary 1-inch pipe. This means that the pressure of 2 p.s.i. from the primary pipe will push water through that pipe and cause it to overflow from the external pipe into the main condenser. To maintain a seal in this assembly it is necessary to retain at all times a level of water in both legs of the loop. This means that under some condition of water level, the pressure of both legs must be balanced so that the water cannot be pushed entirely out of the loop. As the water level is pushed down in the primary leg, water overflowing into the main condenser causes the level in the main condenser leg to remain stationary clue to the overflow into the main condenser. When the level of the primary leg is about 3 feet below the level of water in the secondary leg, the additional weight of water present in the secondary leg will provide the extra 1 1/2 p.s.i. necessary to counteract the 2 p.s.i. absolute pressure against the primary leg. Thus a static condition will be obtained with the water level in the primary leg 3 feet below that in the secondary leg. If water is added to the primary leg from the inter-condenser the level on that sick will rise and the additional weight of water will cause water to be pushed over into the main condenser from the secondary leg thereby restoring the loop to its original



THE LOOP SEAL
FIG. 13

of air reach the **Y** where the two loops separate, the water from the external pipe would flow through the outer loop and passing into the inner loop, prevent that bubble of air from reaching a point which could cause breaking of the seal. The filling connection shown allows condensate to be pumped directly from the main condensate pump and discharged into the loop seal in order to provide for positively filling the loop before placing it in operation. A valve is provided at the main condenser

static condition. In this way water is drained from the inter-condenser back to the main condenser by adding water to one side of the loop and removing it from the other side. This causes the maintenance of a solid body of water in the base of the loop and prevents the passage of air through the loop to cause equalization of vacuum. The total height of this loop seal is approximately 7 feet 3 inches, and in order for the difference in water level to become great enough to allow for emptying of the loop the difference in vacuum between the two condensers must be about 7 inches. Since it is practically impossible for this to occur, the loop should never become unsealed unless initially placed in operation without sufficient water or unless a bubble of air enters the base of the loop. To prevent breaking of the seal, due to the entrance of a bubble of air, the external pipe and the large loop are installed. Should a bubble



DEAERATING TANK
FIG 14

to cut off drainage from the loop seal. Closing this valve will provide another means for filling the loop seal. If it is closed, drains from the inter-condenser will not be allowed to pass into the main condenser and, therefore, will remain in the loop seal and eventually fill it. This method, however. should be used only in case of a casualty to the filling connection. Should the seal become broken it will be readily apparent by an inspection of the vacuum gages on the main and inter-condensers; they will both show the same vacuum. This vacuum will he slightly higher than normal for the inter-condenser and far less than normal for the main condenser. Opening the filling connection valve for several minutes should correct this condition unless there is an air leak in the loop. If an air leak exists, it will be necessary to correct it before the loop will remain properly sealed.

6. DEAERATING FEED TANK

(a) General Discussion.-Water from the main condenser, having been discharged from the main condensate pump, passes through the main air ejector and finally into the deaerating feed tank. This tank has three functions, namely (1) to free the condensate of all entrained oxygen and air, as indicated in the discussion of the steam cycle; (2) to heat the water to a degree which will allow the economizer to introduce all the further heat.required before discharge to the boiler and; (3) to act as a reservoir in which to store water to take care of rapid increases in feed requirements and to store surges in condensate. The deaerating feed tanks installed in the DD445 class destroyers are of two general types, (1) of Cochrane design and (2) of Elliott design. All destroyers of the DD692 class, have installed deaerating feed tanks of the Elliott design. Both types of tanks operate on the same basic principle, the method of construction being slightly different. Since the operation of the Cochrane tanks seems easier to discuss, we will explain its operation first and later note the differences in detail and operation of the Elliott tank.

(b) Operation.-The water enters the tank through the condensate inlet header shown on figure 14. From this header it passes through a nest. of tubes. This nest. of tubes is a heat exchanger and is termed the preheater and vent

condenser. Vapor and air pass around these tubes on their way to be exhausted from the tank, thereby heating the water in the tubes as well as accomplishing condensation of the vapor entrained with the air. From this preheater the water passes into the water box. Extending from the water box is a series of eight spring loaded nozzles, so designed that when water is discharged under pressure it is broken up into a fine spray. This spray is discharged into the dome of the tank where it is restricted into the center of the tank by a circular baffle attached to the tank top. Breaking up the water into this fine spray, while in its partially heated condition, causes a great amount of the entrained oxygen and air to be released. After striking the baffle and the top of the tank the water drops downward and is caught by the inverted conical baffle shown in the sketch. It is directed along this baffle to its base and then drops vertically down around the steam control valve. Steam enters the tank from the auxiliary exhaust line through the connection shown on the left. It passes through the pipe into the center of the conical baffle and down onto the top of the steam control valve. Passing through the ports of this valve, the steam is sprayed out and deflected upward by the flanged disk of the valve. The water dropping vertically from the conical baffle is picked up by this spray of steam and driven along with it. This causes the water to be heated and scrubbed by the steam, thereby releasing all oxygen and air from solution with the water. This mixing of water and steam causes condensation of part of the steam which, with the water, falls to the bottom of the tank. The uncondensed steam rises in the tank outside the conical baffle, carrying the liberated air with it and, passing around the baffle in the path shown, enters the dome of the tank where it mixes with the water being discharged from the spray nozzles. Here, the steam is mixed with the water spray and condensed. The freed air, plus a small amount of vapor, travels from the dome through the baffles in the preheater and vent condenser, where the adjusted that the valve will automatically vary its opening to admit sufficient steam to the tank to maintain the tank pressure at a point which is 2 p.s.i. less than the pressure of steam in the auxiliary exhaust line. This figure of 2 p.s.i. has been arrived at by considering the steam velocity necessary to drive out all the absorbed oxygen and air from solution with the water. Experiment has shown that the velocity obtained through this valve with an existing pressure drop of 2 p.s.i. is sufficient to do this. Should increased load be placed on the tank, and additional water be pumped to it, this would cause increased condensation of the steam in the tank, thereby reducing the pressure. This reduction in pressure would cause a greater drop between auxiliary exhaust and the tank pressure. Consequently, the steam control valve would open wider and admit more steam to maintain the drop still at 2 p.s.i. Should the load he reduced less water would enter the tank and the tank pressure would tend to rise. The rise in pressure would reduce the drop through the control valve, thereby causing the control valve to close and reduce the amount of steam admitted to the tank. Attached to the control gear is a manually operated device by which the degree of maximum valve opening can be controlled. By turning the handwheel until its pointer shows the desired percentage. the setting of the steam control valve can be adjusted to any specific percent of maximum opening. When adjusted in this manner the control gear prevents the valve from opening beyond the figure set on the percentage scale but will not prevent the valve from closing below that figure. Under normal operation, it will be only necessary to set the handwheel at 100 percent and leave it there. The valve will then operate automatically at any and all conditions of load to maintain the tank pressure at a point which is 2 p.s.i. less than that of the exhaust line. The only time it should be necessary to operate the hand control wheel is when it is desired to hold the deaerating tank at a pressure which is lower than 2 p. s.i. less than the exhaust pressure. This might occur when for some reason the auxiliary exhaust cannot

vapor is condensed and the air exhausted from the tank through the vent box.

(c) Steam Control Valve.-The steam control valve, mentioned above, controls the amount of steam admitted to the deaerating feed tank. The degree of opening of this valve is controlled by an arrangement of springs and weights attached externally to the tank. This control gear is so be controlled and rises to a pressure which would allow the temperature in the deaerating feed tank to rise to an excessive height. The temperature of water in the base of the deaerating feed tank will always be at a temperature which is equal to that of saturated steam at the pressure existent in the tank. If the

pressure in the tank is at its normal level of about 13 p.s.i. the temperature of water in the hot-well should be approximately 240 degrees F. Should the tank temperature rise too high for normal operation, due to some external means such as the high-pressure drains, a recirculating connection is provided leading from the base of the tank into the main condenser. This will provide increased circulation through the tank and the water will be discharged back into it after being cooled by the condenser, thereby causing a reduction in pressure and temperature within the tank. When securing it is very frequently necessary to use this recirculating connection. If the tank tends to overheat due to high pressure drains. closing the steam inlet will not reduce the temperature since the steam control valve will close any way when the tank pressure rises above 2 p.s.i. less than the auxiliary exhaust pressure.

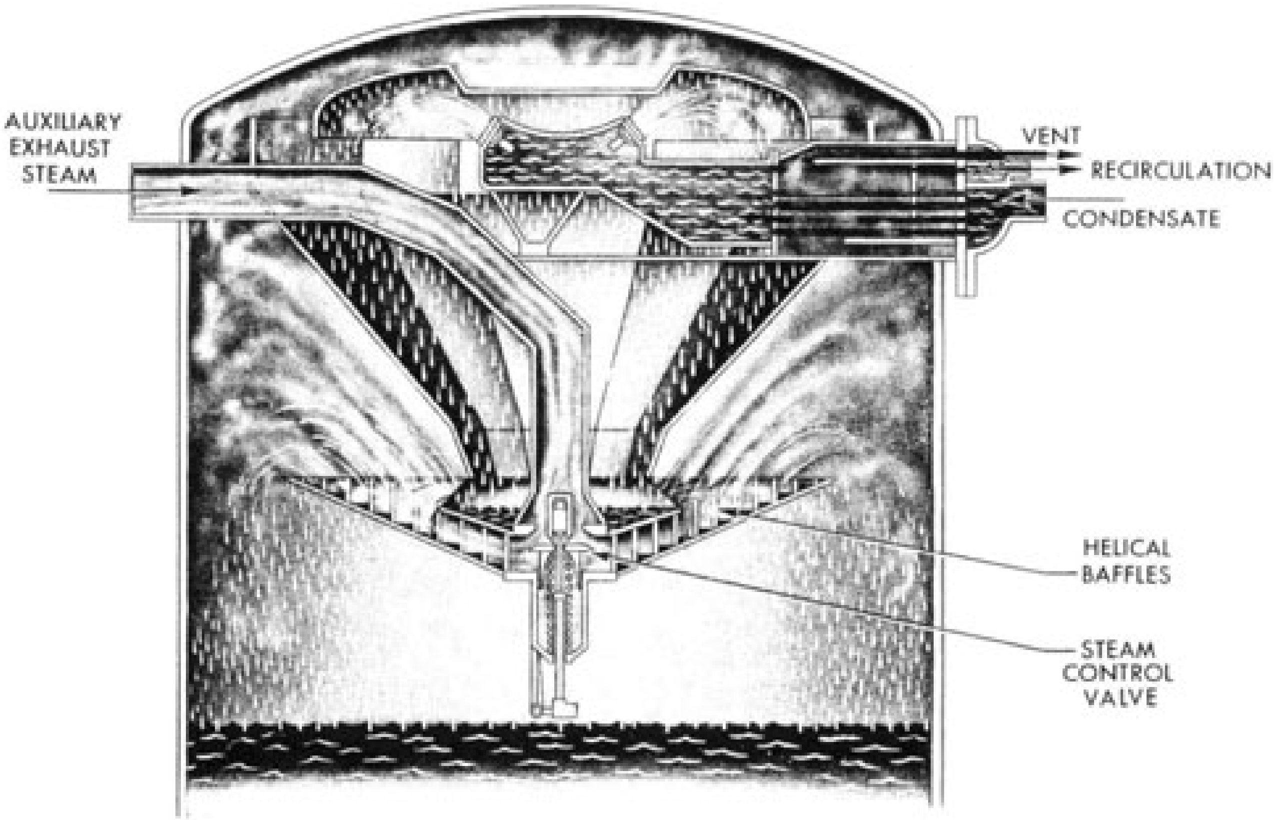
(d) Condensate Recirculating System.-It will be noted that the water inlet header is divided into two compartments. Condensate flows into the lower one and, passing through the lower rows of tubes, discharges against a vertical baffle. This vertical baffle directs the water to the upper part of the water box where it is communicated to he single upper row of tubes. This upper row of tubes leads into the upper compartment of the inlet header. Water can flow back through this upper row and be removed through the recirculating vent condenser, and flows under pressure into the water-box. Here appears the first difference in operation. The spray nozzles extending from the water-box are spring loaded to open all at once. There are 12 nozzles in all, so designed as to open at a very low pressure and maintain good atomization even under very low loads. The water spraying from these nozzles is retained in the center of the tank by the baffle shown and drops into the conical baffle. At the base of the conical baffle a cup-shaped recess catches the water. Surrounding this cup-shaped recess is another baffle in the shape of an inverted cone which carries in it baffles extending from its center in a helical shape. The overflow of water from the cup-shaped recess drops into these helically shaped baffles. Steam enters the tank from the auxiliary exhaust line through the pipe shown at the left and is led down on top of the steam control valve. The steam control valve in this tank does not act to effect deaeration as in the Cochrane tank but is merely a check valve to prevent excessive pressure in the tank from backing into the auxiliary exhaust line. Due to the presence of the helically shaped baffles a specific pressure drop is not necessary to accomplish deaeration. The valve is wide open whenever the tank is operating normally, and the flow of steam into the tank is controlled by the rate of condensation of steam in the tank. Under normal conditions the pressure drop between auxiliary exhaust line and tank will be one-half p.s.i. or less. At low loads the water overflowing the cup-shaped recess will fill the space within the conical

connection from the tank before it has passed into the tank. A discussion in detail as to methods of operation of this recirculating system will appear in the general discussion of the main condensate piping system.

(e) Feed Water Level Control.-Methods of controlling the water level in this tank can only be fully understood if discussed in connection with the piping system and, therefore, this discussion also will appear in connection with the condensate piping system.

(f) Elliott Deaerating Feed Tank.-Some destroyers of the DD445 class and all destroyers of the DD692 class have the Elliott deaerating feed tank installed. The purpose of this tank is the same as that of the Cochrane tank, but its method of accomplishing this purpose and some of its details of construction differ. An inspection of figure l will show this difference in construction.

(g) Operation.-The condensate flowing from the air ejector enters the tank in the same manner as the Cochrane tank, through a Preheater and baffles. This will cause a cessation of steam flow until the tank pressure has decreased, by condensation, to the point where the pressure drop is great enough to cause steam to blast through the leg of water in the helical baffles. This continuously repeating action drives the water out of the baffles and at the same time accomplishes the deaeration necessary. At higher loads the rate of steam flow is great enough to prevent the accumulation of water in the helical baffles, the steam driving the water out as it overflows the cup-shaped recess. This effects the deaeration at higher loads. The only pressure drop appearing at the higher loads is due to the friction encountered by the steam in passing through the helical baffles. A shaft extends from the steam valve through the side of the tank and has a lever attached to it. When this lever is thrown in one direction it presses a collar against the check valve



THE ELLIOTT DEAERATING TANK
FIG 15

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and forces it fully closed. When the lever is thrown in the opposite direction another collar forces the check valve open. When the lever is locked in the center neither collar bears and the valve is free to operate automatically. Except for the above discussion, all instructions anti notes on the operation of the Cochrane deaerating feed tank apply as well to the Elliott tank.

7. CONDENSATE SYSTEM PIPING

(a) General Discussion.-The main condensate system is composed of the following elements: (1) the main condenser hot-well; (2) the main condensate pumps; (3) the main air ejector; (4) the loop seal; and (5) the deaerating tank. We have discussed the operation of these separate elements individually in earlier pages so we will here discuss the manner in which they are piped together to function as a system. The piping

This is the excess feed line which will be fully discussed when we take up that system. Leading off from the 5-inch line by the deaerating tank, there is a 3 1/2-inch branch. In this branch there is a cut-out valve, and the line finally joins with the condensate system in the after engine room. This forms the cross-connection between the two condensate systems. Entering the condensate line before the deaerating tank, is a branch leading from the auxiliary air ejector. This is the condensate discharge line from the auxiliary plant to provide for operation of the deaerating feed tank when operating the auxiliary plant. In addition, there is in the forward plant only, a branch line leading from the evaporator first-effect coil drain pump and discharging into the condensate discharge line, as shown on the sketch. Condensate from the evaporator first effect coils is hot and. therefore, its discharge directly into the deaerating tank will retain this heat. This condensate can also be discharged

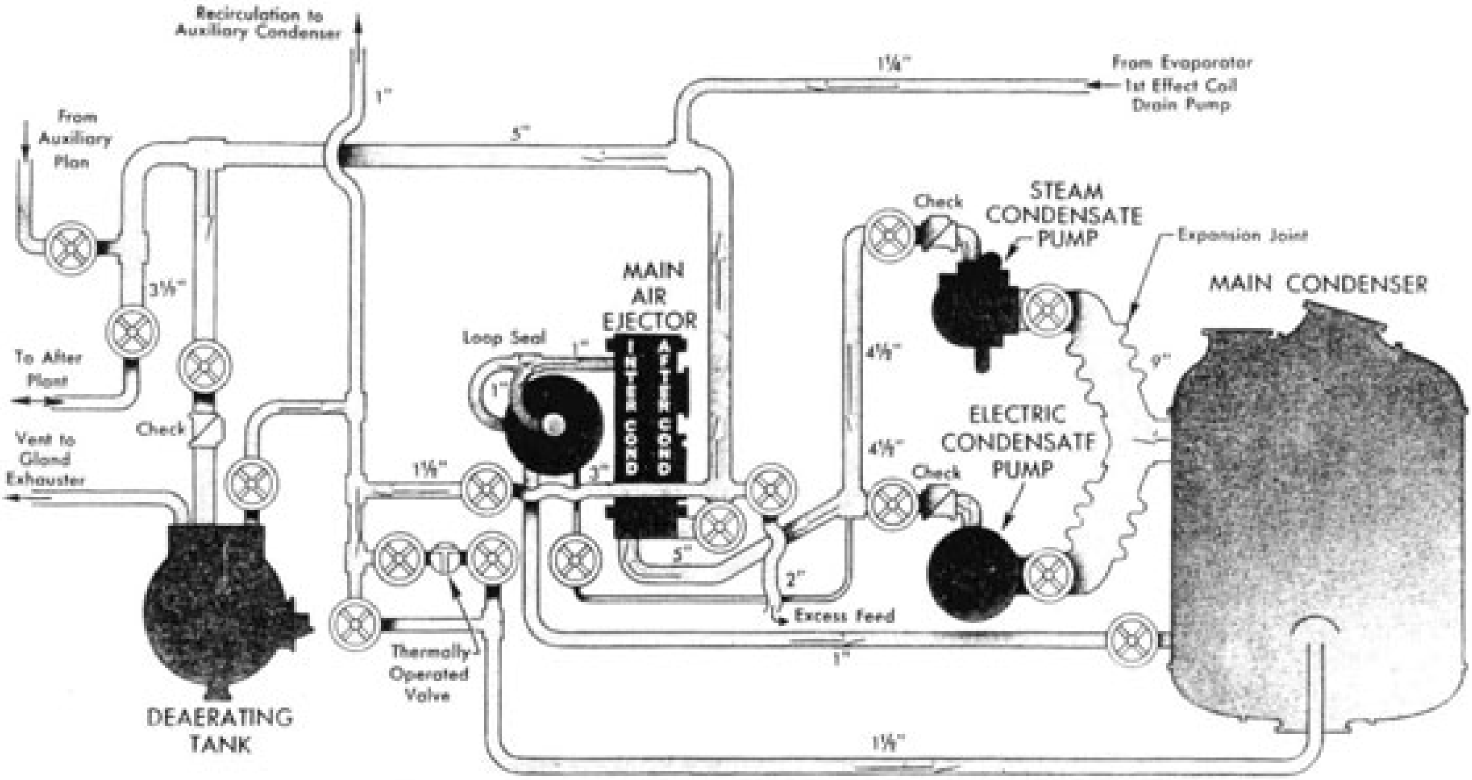
description which follows applies to the forward engine room. The differences between that and the after engine room piping will be noted later.

(b) Piping.-The main condenser hot-well serves as a primary reservoir of condensate. From here the main condensate pumps take suction through a 9-inch line which branches to each pump. In this line ahead of each pump is a corrugated expansion joint, followed by a gate valve. This expansion joint absorbs the expansions and contractions of the pipe and prevents it from putting a stress on the pump casing. The valve serves merely as a suction cut-out valve. Water discharging from the pump passes first through a vertical check valve, then through the pump discharge cutout valve and finally into a 4 1/2-inch discharge riser. These risers from both pumps join together into a common 5-inch discharge line which leads to the inlet of the inter-condenser of the main air ejector. Here the condensate passes through the inter-, after-, and gland-seal condensers of the main air ejector, finally leaving the air ejector through a line cut-out valve. It should be especially noted here that there is no valve on the inlet to the main air ejector, thus making it impossible to have the condensate pumps operating without at least having water in the air ejector condensers. From the outlet valve of the air ejector, a 5-inch line leads the condensate overhead and finally to the deaerating feed tank through a cut-out valve and a check valve. From the outlet side of the air ejector discharge valve a 2-inch branch leads through a stop valve into the make-up and excess feed system.

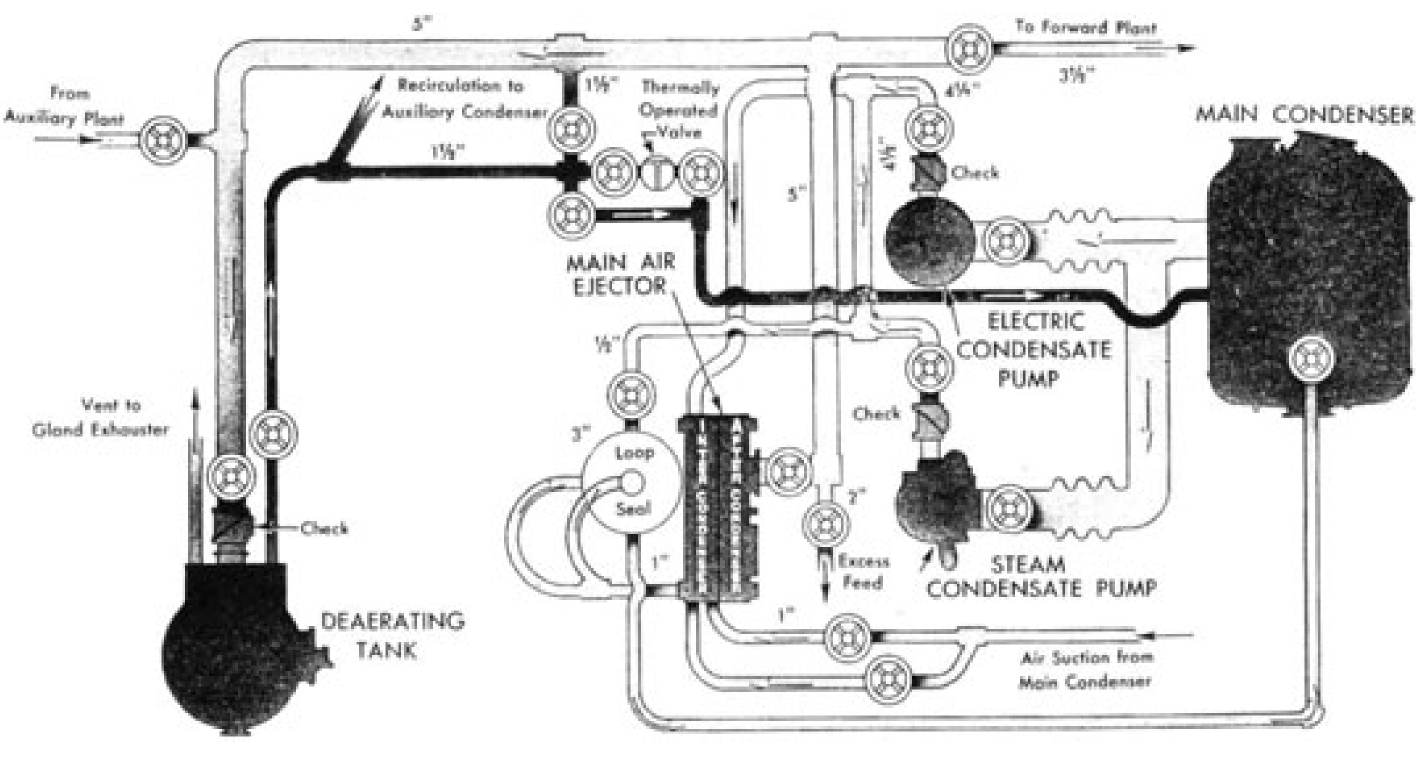
into the low pressure drain system, but where this is done it would have to pass through the main condenser where it would be cooled and the heat lost. Air suction from the main condenser is led through a 6-inch line which branches into two 5-inch lines, one leading to each first stage air ejector nozzle. Condensate from the inter-condenser passes through a 1-inch line. through the loop seal, finally discharging into the main condenser. The loop seal filling line leads directly from the condensate pump common discharge line into the external pipe of the loop seal.

The above description applies in detail to the condensate system of the DD445 class. The DD692 class is similar except for the installation of the 4,000 gallons per day distilling plant in the after engine room requires a connection from the first-effect tube nest drain pump of this plant.

(c) Recirculating System.-Operation of the main condensate pumps requires that water be provided at all times for suction to these pumps. If steam is not entering the main condenser to provide condensate for this suction, arrangements must be made for recirculating water from the discharge side of this pump through the air ejector condensers and back to the main condenser hotwell. This arrangement is made to lead water from the condensate system on the outlet side of the main air ejector. Two sources are provided for this recirculating water, one from the recirculating connection on the deaerating tank, as indicated in the discussion of that tank, and the other from



CONDENSATE SYSTEM
#1 ENGINE ROOM
FIG. 16



CONDENSATE SYSTEM
#2 ENGINE ROOM
FIG. 17

the condensate discharge line before the deaerating tank. Both of these connections lead to a thermally operated valve, through this valve and finally into the main condenser. A bypass around this thermally operated valve is provided to allow recirculation when the valve may not operate. This thermally operated valve is controlled by means of a capillary unit placed in the circulating water header of the main air ejector. When the temperature of the water in this header rises above 140 degrees F., the valve will start to open automatically and provide passage of water from the condensate line back to the main condenser, thus setting up additional circulation through the air ejector. When warming up the plant, however, the thermally operated valve will not open soon enough to prevent the main condensate pump from burning up in case all water is pumped from the main condenser hotwell. In order to provide circulation back to the main condenser hot well, the bypass around the thermally operated valve should be opened to maintain water suction for the condensate pump It is recommended that water not be led from the deaerating tank to provide this recirculation but that water be taken directly from the condensate line before the deaerating tank. If the deaerating tank is not to be placed in operation this will be necessary but even though the deaerating tank is in operation it is still desirable to use this connection. In any case, whenever there is insufficient steam entering the main condenser to provide proper suction for the main condensate pump it will be necessary to recirculate water back to the main condenser through the bypass around the thermally operated valve. The thermally operated valve is valuable only when the plant is being operated at very low rates which will provide sufficient water flow condensate system provides cooling water for the condensers of the main air ejectors, it is necessarily the, first system to be placed in operation when warming up the plant.

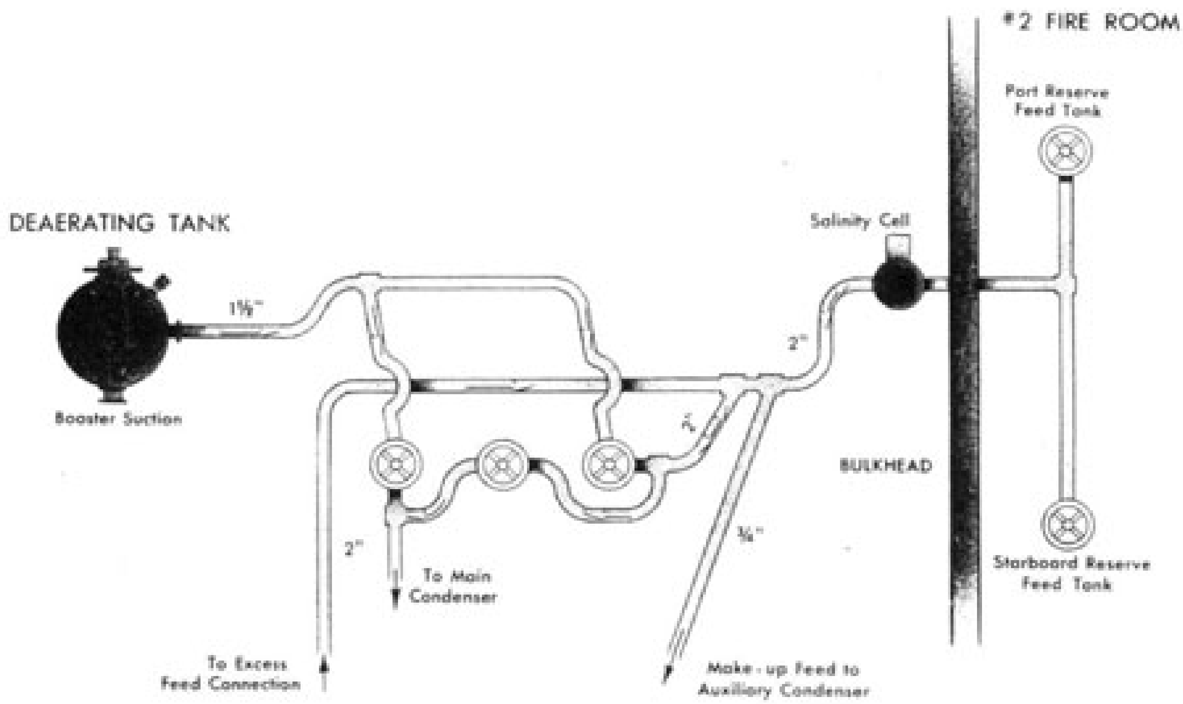
(d) Water Level Control.-Controlling the water level in the deaerating tank is done by use of the make-up and excess-feed valves. The makeup feed valve provides additional water in the main condenser for discharge into the deaerating tank. The excess-feed valve leads water from the condensate discharge line before the deaerating tank and provides for its return to the reserve feed tanks. Adjustment of these valves can be made to maintain a constant level of water in the deaerating tank. When maneuvering it will he noted that the deaerating tank level will not remain constant, but will surge up and down at times as much as a foot. These surges are not actually changes in the amount of water in the system but are merely apparent changes, since a change in the rate of evaporation in the boilers may cause a greater or less percentage of the feed water in the system to be in the engineroom. An increase in speed will cause an increase in the amount of water carried in the engineroom and a decrease in speed will cause a decrease in that amount of water. due to the increased or decreased volume of steam present in the boiler. When maneuvering, a condition of this sort is only temporary and when operation is returned to normal, the water level in the deaerating tank will also return to normal. Under these conditions do not attempt to keep the water level constant.

(e) After Plant.-The arrangement of the condensate system in the after engineroom is the same as that in the forward engineroom with the following

through the condensate pump to prevent its burning up but insufficient flow through the main air ejector to prevent its overheating. This means that the recirculating line from the deaerating tank should be left open when underway and that the cut-out valves around the thermally operated valve should be left open to allow for operation of this valve when necessary. When underway. the bypass around the thermally operated valve should be closed. Whenever sufficient steam is being discharged into the main condenser, from whatever source, to keep sufficient water in the hot well for suction to the main condensate pump the recirculating system may be set up on the thermally operated valve. Since the

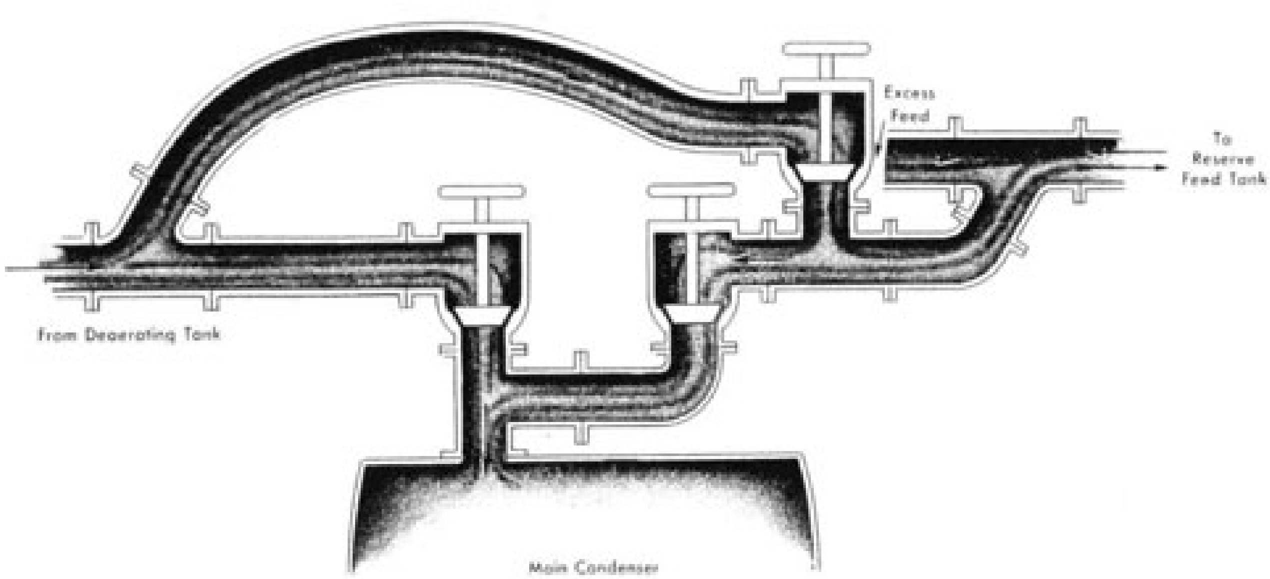
exceptions. The condensate cross-connection line, leading from the after system. lasses forward through its own valve, and joins the forward system close by the outlet side of the main air ejector. The evaporator first-effect coil drain pump discharge line does not appear since the evaporator is only in the forward engineroom. In the case of the DD692 class, there is an evaporator first effect coil drain line leading into the condensate system aft because in this class of ship a 4,000 gallon per day distilling plant is installed in the after engineroom.

f) Make-up and Excess Feed System-The make-up and excess-feed system appears as a service system to the main condensate system. Its purpose is to provide additional fresh water for



MAKE-UP AND EXCESS FEED
#2 ENGINE ROOM
FIG. 18

the main feed system to take care of loss in water throughout the steam cycle and also to provide a means to return water to the reserve feed tanks when a change in rate of steaming makes this necessary. Each engine room can take make-up feed water only from the reserve feed tanks in its own fireroom. A 2-inch line leads from each reserve feed tank, with a valve at each tank, and. joining together, passes through the bulkhead into the engine room. Just inside the engine room is a salinity cell which indicates on an instrument at the main gage board the salinity of the reserve feed water. This same line leads aft, over the main condenser, and into a three-valve manifold attached to the main condenser. Through the center valve of this three-valve manifold water can be drawn from the reserve feed tanks, by the vacuum in the main condenser. The excess-feed line, shown also in the condensate systems, leads water from the outlet side of the main air ejector into this 2-inch line and allows for water to be pumped under pressure, back into the reserve feed tank. It is apparent then that the same pipe line is used to take make-up feed from the reserve feed tanks that is used to discharge excess feed back into these same tanks. From the bottom of the deaerating tank a 1 1/2-inch line leads to the forward and after valves of this three-valve manifold. The after valve will allow water to be run from the deaerating tank back to the main condenser and the forward valve will allow water to be run from the deaerating tank into the reserve feed tanks. Figure 19 shows how this is done. On starting tip the main condensate pump. it is necessary to provide water in the main condenser hot-well for the condensate pump suction. The after valve will allow water to be run from the deaerating tank for the purpose. To take makeup feed water into the auxiliary condenser an additional branch is provided from the 2-inch line leading directly into the auxiliary condenser. Discharging into this same line is the distiller fresh water distributing pump which allows fresh water from the evaporator to be discharged directly into the make-up feed system or to the reserve feed tanks. When under normal operation if the water



MAKE-UP AND EXCESS FEED
#1 ENGINE ROOM
FIG. 19

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Level in the deaerating tank begins to drop, we can replenish the condensate system with water from the reserve feed tanks by opening the center valve of the manifold and drawing water in to the main condenser. Before opening this valve to connect the "vacuum drag" up to the main condenser you must insure that there is sufficient water in the reserve feed tank being drawn on to prevent the suction of air into the condenser. Failure to do this has very frequently been the cause of a casualty involving loss of main condenser vacuum. When the water level in the deaerating tank rises too high we can return some of this water to the reserve feed tanks by opening the excess-feed valve. This excess-feed valve, being after the main air ejector. allows a full flow of water to pass through the air ejector condensers and takes it off, afterwards, to return to the reserve feed tank. Under certain conditions the run-down valve from the base of the deaerating tank may be used as a recirculating valve. If the deaerating tank temperature is held too high due to excessive high pressure drains, opening this run-down valve will provide recirculation front the deaerating tank back to the main condenser before discharging it back into the deaerating tank thereby causing the deaerating tank to be carried at a lower temperature. The arrangement of both make-up and excess-feed systems is exactly the same in both engine rooms. For the DD445 class, there is no discharge into the after system for the distiller fresh water distributing big pump, but in the DD692 class a discharge is provided from the pump of the small distilling plant in the after engine room.

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Section V

FEED WATER SYSTEM

1. GENERAL DISCUSSION

The feed water system can be broken down, for better presentation, into three separate systems: first, the main feed booster system; second, the main feed system; and third, the emergency feed system. With one exception, the elements of all these systems will be discussed before discussing the piping system. The main feed booster system is that part of the feed system in which water flows from the deaerating tank through the main feed booster pumps and up to the suction of the main feed The main feed system is that part of the system which carries water from the main feed pumps into the boilers. The emergency feed system is that part of the feed system through which water can be fed into the main feed system through the emergency feed pump and through which water can he transferred from one plant to another. The one exception, which will be discussed after the discussion of the feed piping, is the feed water level regulator which is so closely related to the boiler that it is best described just before starting the description of the boiler.

2. MAIN FEED BOOSTER PUMP

(a) General Discussion.-The main feed booster pump takes suction from the deaerating tank. This is a vertical, centrifugal, single-stage pump. which operates in principle the same as the main condensate pump except that there is only one impeller in this pump. Normally, since the deaerating tank is under pressure, the suction of this pump is also under pressure. The flow of water through this pump is the same as that described for the condensate pump with the exception, of course, that there is only one stage. This pump operates under a total head of

(b) Wearing Rings.-In this pump there are two sets of wearing rings of approximately the same design as those in the condensate pump. The clearance between these rings is approximately 0.008 inch, and they should be renewed when they wear to 0.030 inch. The upper rings shown seal the discharge from the suction side and the lower rings seal the discharge from passing back into the suction side through the equalizing ports of the impeller.

(c) Driving Mechanism.-In the DD445 class destroyers there is installed one electrically driven main feed booster pump and one turbine-driven main feed booster pump. The motor of the electrically driven pump is directly connected to the pump shaft. Therefore they run at the same speed, approximately 1,150 r.p.m. Externally the steam pump appears to be the same as the steam main condensate pump. The turbine operates at approximately the same speed as that of the condensate pump (5,300 r.p.m.), while the pump end operates at approximately 1,150 r.p.m. The major difference between the main condensate and the main feed booster pumps is in the capacity of the two pumps. The capacity of the main feed booster pump is approximately 455 g.p.m.. while that of the condensate pump is approximately 325 g.p.m. Time need for the increase in capacity of the main feed booster pump is because of the drains and auxiliary exhaust steam which enter the deaerating tank. This makes the volume of water entering the deaerating tank, from all sources, considerably greater than the volume of water entering the deaerating tank from the condensate line. Whenever it is necessary to operate more than one main feed booster pump it is essential that the same number of main condensate pumps be in operation in order to insure sufficient water for suction to the main feed booster pump. In the DD692 class, both main feed booster pumps are

approximately 35 p.s.i. This means that the difference between suction and discharge pressures must equal 35 p.s.i. That is, if the suction pressure is 15 p.s.i. at full load the pump will discharge 50 p.s.i. Normally the deaerating tank will carry from 13 p.s.i. to 15 p.s.i. pressure. This, plus the head of water above the booster pump suction, will make the booster pump full load discharge pressure about 50 p.s.i.
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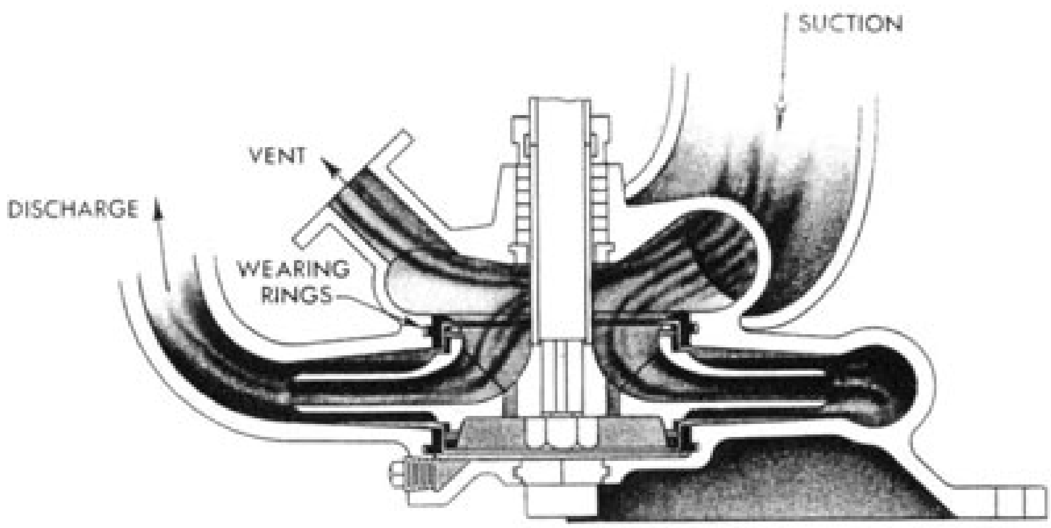
turbine driven pumps.

(d) Lubricating Oil System.-The same lubricating oil system is installed on the main feed booster pump turbine as that on the main condensate pump turbine.



MAIN FEED BOOSTER PUMP
FIG. 20

(e) Limit Speed Governor.-The limit speed governor which controls the main feed booster pump is of the same design as that controlling the main condensate pump. There is one difference, however, and that is that the total governor travel of the main feed booster pump should be adjusted to three-sixteenths inch instead of the one-fourth inch specified for the condensate pump.

(f) Operation.-The normal operation of this pump is with a deaerating tank pressure of 13 to 15 p.s.i. It is not essential to have more than atmospheric pressure to the suction of the pump in order to prevent it from overheating. This means that the pump can be operated with the deaerating tank under no pressure if the temperature of the water and discharging against a closed valve, there will be no circulation through the pump to carry away this heat. Should vapor or air enter the impeller. this may vapor bind the pump and prevent the flow of water to carry away the heat. These are the same probabilities of casualty which were discussed in connection with the condensate pump. We must have means to prevent occurrence of casualty through any of these means. A vent connection is provided from the suction casing of the pump leading back to the deaerating tank, which is the original source of supply. Operating the pump with this connection open at all times will tend to prevent the pump from becoming vapor-bound. To insure against operation of the pump without flow of water through it, that is, operation when a main feed is not taking suction

is less than 212 degrees F. It is not possible to put a vacuum on the suction side of the main feed booster pump since the deaerating tank itself is fitted with a vacuum breaker to prevent the formation of such vacuum in the tank. Should the deaerating tank become empty, however, the pump will run for only a few seconds before the wearing rings will overheat and seize due to the lack of circulation of water in the pump to carry away the heat. If the pump is operating from the pump discharge, a recirculating connection is provided. This recirculating connection leads from the discharge line of the booster pump into the deaerating tank where it discharges above the conical baffle in the deaerating tank. This means that water passing through this recirculating line must also pass the steam control valve in the deaerating tank and thereby be scrubbed free of air. Whenever a booster pump is operating

without a main feed pump also in operation, this recirculating line must be open to provide continuous circulation through the main feed booster pump. A smaller recirculating line (three-fourths of an inch) is provided, bypassing around the main 2-inch recirculating valve. This three-fourths of an inch line should be open and the 2-inch valve closed when warming up the main feed pump. When the main feed pump is put on the line, discharging to the boilers, this three-fourths of an inch valve should also be closed. The recirculating line from the main feed pump, later discussed, will provide sufficient flow through the main feed booster pump should feed be suddenly stopped. It is desirable to leave the three-fourths of an inch line open when the main feed booster pump is discharging to an emergency feed pump since it, being a reciprocating pump, will take a varying suction from the booster pump. Under no circumstances should the 2-inch recirculating valve ever be allowed to remain open when a main feed pump is operating. This 2-inch valve will pass very nearly the full capacity of the main feed booster pump and, therefore, should the main feed pump be operating at the same time it might reduce the main feed pump suction pressure below that required. If the main feed pump recirculating connection provides sufficient circulation to prevent the main feed pump from overheating it will certainly provide sufficient to prevent the main feed booster pump from and some are three-stage pumps, but the action of water in all and the necessary precautions are the same. There are two of these pumps installed in each engine room, both turbine driven. The speed of rotation is very high, approximately 5,500 r.p.m. Since the pumps are directly connected to their driving turbines, the pump impellers operate also at the same speed.

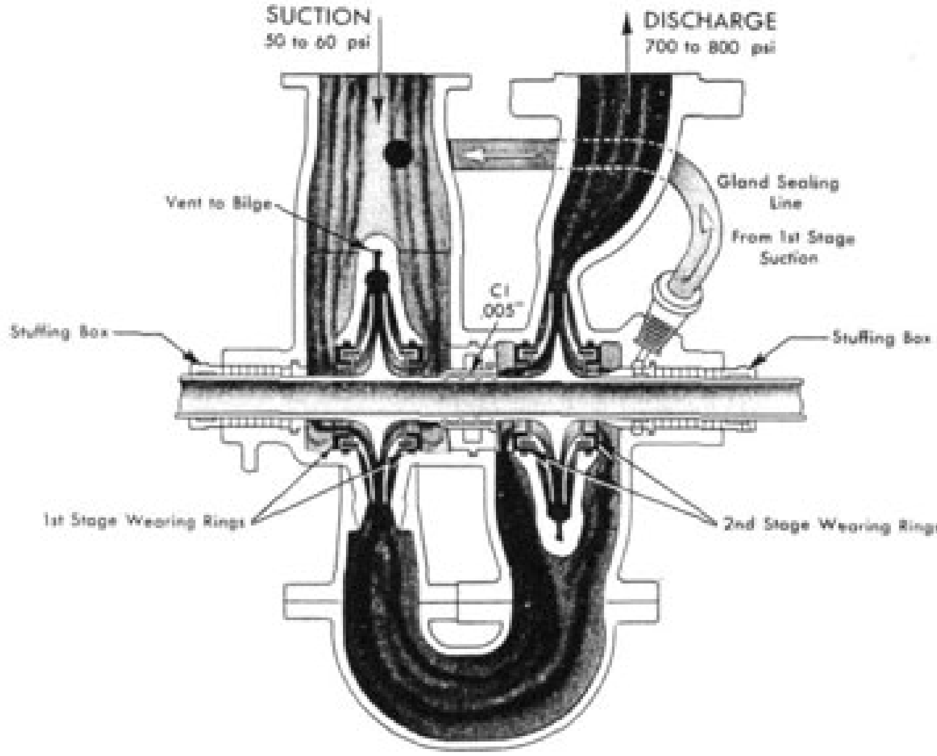
(b) Operation.-The main feed pumps take their suction directly from the discharge line of the main feed booster pump. This means that the suction to these pumps is under a normal pressure of from 50 to 60 p.s.i., depending upon the load on the pump. Figure 21 is a sketch of a Buffalo pump. As indicated previously, the action within this pump is very similar to that within all other main feed pumps. Water enters the first-stage suction casing from the main feed booster pump under pressure and is discharged through the first-stage impeller into a built-in connection which leads to the suction of the second-stage impeller. Passing through the second-stage impeller, water is discharged under high pressure (approximately 750 p.s.i.), into the main feed line. There are two sets of wearing rings in each stage since the impellers are double entry. The designed clearance for these rings is approximately 0.008 inches. Since these rings have the same clearance as those in the condensate and feed booster pumps, and the pump speed of rotation is five times as great, it is obvious that the possibility of seizure

overheating. When warming up a plant in which the deaerating tank has been secured and allowed to get cold it should be standard practice to operate the main feed booster pump for at least half an hour, recirculating through the deaerating tank, before feeding to the boiler from that tank. This will allow the removal of oxygen which may have been absorbed during the idle period and will also provide for heating up water standing in the tank. It cannot be too greatly stressed that when a main feed pump is started up, taking suction from the main feed booster pump. the 2-inch recirculating valve from the main feed booster pump should be closed.

3. MAIN FEED PUMP

(a) General Discussion.-The main feed pumps installed in both the DD445 and DD692 classes are horizontal pumps directly connected to their driving turbines. The impellers of some are either double or single entry and others have both single- and double-entry impellers. Some are two-stage

of the rings is also much greater. This pump is subject to the same casualties as the main condensate and main feed booster pumps, and is even more subject to these casualties due to the high speed of rotation of the pump. Water entering the suction of the first stage from the booster discharge line has its pressure reduced while passing through the entrance ports and since this water is under a temperature of about 240 degrees F., this reduction in pressure might easily be the cause of the water flashing into steam. Should this occur the first-stage impeller will become vapor bound and prevent the flow of water to the pump to remove the generated heat. Should this pump become vapor bound it will require only about 15 seconds for the pump to overheat and seize, due to the high speed of rotation. It is essential that the pressure leading to the pump suction from the main feed booster be maintained at as high a level as possible. Under no circumstances should a main feed pump ever be turned over unless there is at least 40 p.s.i.



MAIN FEED PUMP
FIG. 21

pressure to the suction of the pump. It should be noted in this connection that if the pressure should ever be this low there must be something wrong with the main feed booster pump. since this pump will discharge a normal pressure of approximately 50 p.s.i. Should vapor enter the pump from any source a vent is provided to carry this vapor away. This vent is only necessary in the first stage since the pressure in the second stage will prevent the accumulation of any vapor. When first starting up the pump this first-stage vent must always be open to carry away any accumulation of air or vapor which may be trapped in the pump casing.

(c) Recirculating Line.-To provide continuous circulation through the pump, a recirculating line is provided leading from the pump discharge connection and discharging into the deaerating tank. A valve is installed in this recirculating line and this valve is provided with a locking device in order that it may be permanently locked open. Under any condition of operation of the main feed pump. this valve should be locked open to provide recirculation. The size of the line here installed is sufficiently great so that a full flow through this line would reduce the possible capacity of the main feed pump materially. Therefore, an orifice is placed in this line to insure that excessive flow will not be bled from the pump. Early installations of this orifice provided only a single plate. drilled with a three-sixteenths-inch hole. This provided sufficient recirculation to prevent overheating of the pump even though the discharge was completely shut off. However, the high velocity of the water in discharging from this single orifice was sufficient to rapidly wear away the pipe between the orifice and the deaerating tank and cause leaks to occur in this pipe. Later installations provide for multiple orifice plates, the purpose of which is to reduce the pressure by steps. thereby reducing the final discharge velocity of the water. Since this recirculating line must always be open, it is not necessary nor is it desirable to open the discharge valve of the main feed pump when warming up this

pump prior to putting it on the line. This discharge valve should be kept closed to protect the check valve until such time as it is desired to feed the boilers from this pump.

(d) Limit Speed Governor.-The maximum speed of this pump is controlled by a limit speed governor of the same general design as has been previously discussed. However, this governor is located horizontally instead of vertically and is on the turbine shaft. The total travel allowed the governor valve in this installation is one-fourth inch. This adjustment must always be checked and reset after a change is made to the governor setting. In order to build up the required pressure the speed of rotation of this pump, even under no load, is very high (approximately 4,500 r.p.m.). This means that the change in speed from no load to full load will he only about 1,000 r.p.m. The governor valve must start to close at some speed before the limit speed. With a limit speed adjustment of 5,500 r.p.m., the governor valve will start to close at approximately 5.100 r.p.m. This means that a condition may occur in which the constant pressure pump governor attached to this pump may be admitting more steam to increase the pump speed while the limit speed governor is reducing the steam admitted to the pump. To prevent this occurrence the limit speed governor of these pumps should be adjusted to limit the speed at a higher level than the rated speed of the pump. That is, the governor should not start to throttle the steam pressure to the pump until the rated speed has been reached. To prevent this, a limit speed setting of about 300 or 400 r.p. m. above the rated speed will be necessary. This condition is very noticeable on the Buffalo pump herein discussed, but for feed pumps of other designs there is not so great a variation.

discussed ill connection with the main lubricating oil pumps. Since the action of this governor is the same as that of the Leslie governor as applied to the main feed pump it will not be necessary to make two explanations. This discussion of the Leslie governor appears under section VII, paragraph 6.

(f) Lubricating Oil System.-Installed with this pump is a self-contained lubricating oil system consisting of a pump, oil cooler, and sump tank. The sump tank is located in the base of the pump and the oil pump takes its suction from there. It discharges through the oil cooler and into a header which leads oil to all bearings. A relief valve is connected to this header which discharges into the sump tank. This valve starts to lift at 10 p.s.i. and should maintain the oil pressure to the bearings at some level between 10 p. s.i. and 15 p.s.i. Due to the high speed of operation of this pump, it is essential that the pump never be brought up to full speed until the temperature of the oil reaching the bearings is at least 90 degrees F. In general, the center bearing of these pumps will be the hottest of the three and should operate at a discharge temperature of between 150 degrees and 160 degrees F.

(g) Operating Notes.-The pump should always be warmed up with the constant pressure pump governor bypassed and steam admitted by using the throttle valve. When the pump is ready to put on the line the constant pressure pump governor may then be cut in. The following is a list of details to check when warming up the main feed pump:

(e) Constant Pressure Pump Governor.-As mentioned above, the discharge pressure from the main feed pump is controlled by a constant pressure pump governor installed in the steam supply line to the pump and actuated by the discharge pressure from the pump. Its purpose is to maintain a constant discharge pressure from the pump under all conditions of loading. Some main feed pumps are fitted with the Foster constant pressure pump governor and some with the Leslie constant pressure pump governor. A following paragraph will present a discussion of the Foster constant pressure pump governor. The Leslie governor is

1. Check lubricating oil level in sump.
2. Check circulating water in lubricating oil cooler. Have water outlet valve from cooler closed.
3. Open suction valve.
4. Check suction pressure-should be at least 50 p.s.i.
5. Check recirculating valve-should be locked open.
6. Open first-stage vent.
7. Open all drains.
8. Open exhaust valve.
9. Bypass pump governor.
10. Crack throttle valve.
11. When drains blow steam, close them.
12. Bring up steam pressure to turn over pump at sufficient speed to set up oil circulation in lubricating oil system.
13. When first-stage vent drains solid water, close it until it is just cracked.
14. Run pump at about 1,500 r.p.m. until the lubricating oil sump temperature reaches 90 degrees F.
15. It is not necessary to open the discharge valve until ready to put the pump on the line. In

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the case of the Worthington main feed pump it must be put on the line within ten minutes after starting. The Buffalo and DeLaval pumps can he idled for warming up indefinitely.
16. When pump is on line, close the first-stage vent fully.

4. CONSTANT PRESSURE PUMP GOVERNOR

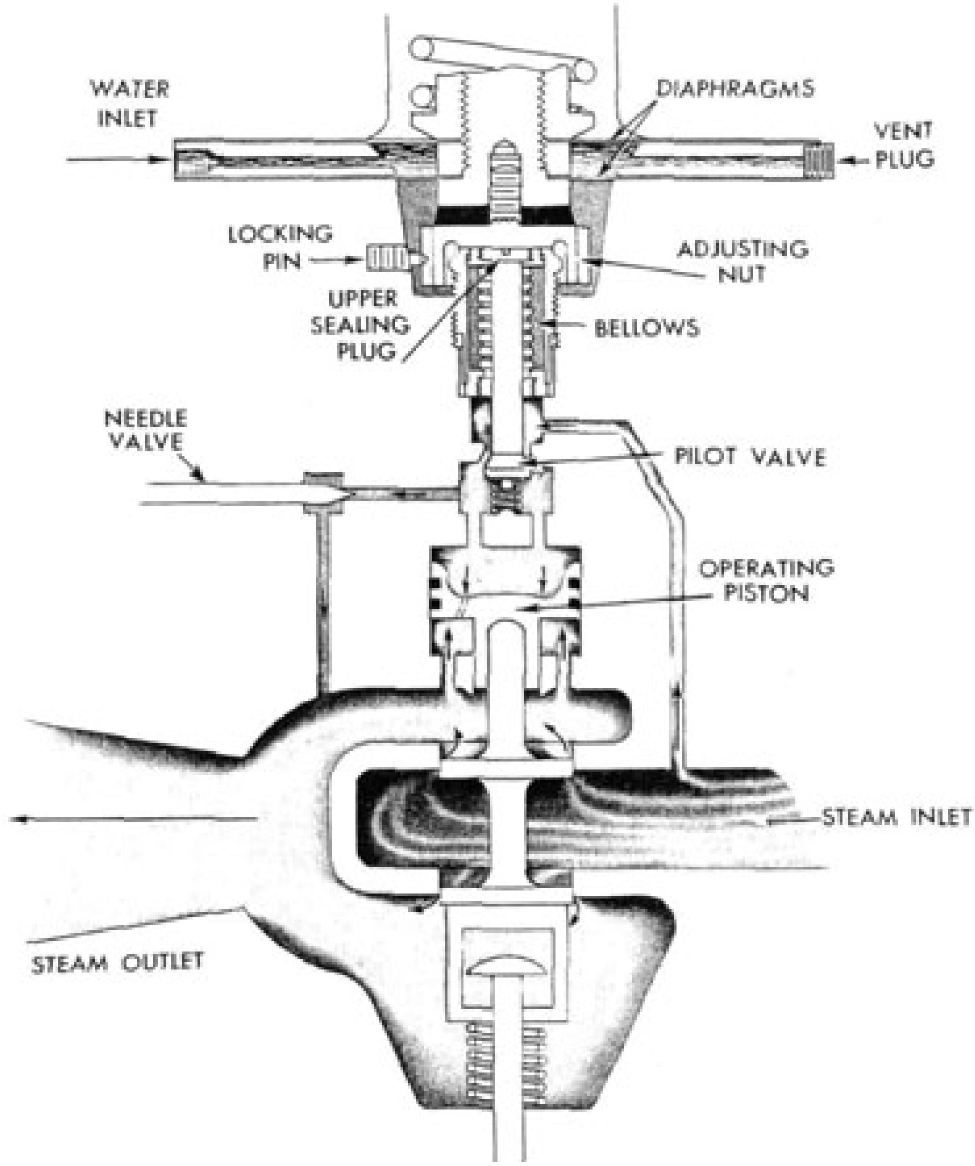
(a) General Discussion.-As previously mentioned, the constant pressure pump governor which controls the main feed pump may be furnished by

resultant upward force on the diaphragms which ultimately causes operation of the governor valve. Should the spring force be greater than the upward force on the diaphragms they will be forced downward. The adjusting nut (fig. 22) is threaded to the diaphragm assembly, so the downward movement is transmitted through this nut tot he upper sealing plug. The upper sealing plug, being in contact with the pilot valve stem, pushes the pilot valve open. The illustration shows a port leading from the steam inlet of the governor valve to the pilot valve. Opening the pilot valve allows steam to pass through to the top of the opening piston. The pressure of this steam forces the operating piston

either the Foster Engineering Company or the Leslie Company. Since the Leslie governor is described (p. 91) in connection with the lubricating oil pumps, the Foster governor will be here described in connection with the main feed pump. This governor is bolted into the auxiliary steam line leading to the main feed pump turbine and controls the steam admitted to the turbine, varying this steam pressure to maintain a constant discharge pressure from the pump.

(b) Operation.-The function of this governor is to vary the steam pressure to the turbine (and consequently the turbine and pump speed) in order to maintain a constant discharge pressure from the pump under varying capacity requirements. It is apparent that some means must be applied to make the changes in capacity requirement cause corresponding changes in opening of the governor valve. With the pump operating at a specified speed, an increase in capacity requirement will cause a decrease in discharge pressure, and a decrease in capacity will cause an increase in discharge pressure. It is these changes in discharge pressure which are used to accomplish actuation of the governor valve. Figure 22 shows a connection labeled "water inlet," at the upper left, which leads into the space between two diaphragms. This "water inlet" is connected by means of an actuating line to the pump discharge and therefore carries the discharge pressure of the pump. The two diaphragms are mechanically tied together by the arrangement shown. It will be noted that the area of the upper diaphragm is greater than the area of the lower diaphragm. The water discharge pressure of the pump will be exerted against both diaphragms but, since the area of the upper diaphragm is greater than that of the lower, the total force exerted will be in an upward direction. Opposing this upward force is a spring pressing down on the upper diaphragm. It is the balance between the spring force and the down, opening in turn, the governor valve. This admits more steam to the pump turbine causing it to speed up and the discharge pressure to increase. This increase in discharge pressure causes the upward force on the diaphragms to become greater than the spring force and the diaphragms will move upward. This will raise the adjusting nut and, releasing the pressure on the upper sealing plug, allow the pilot valve to close down. The consequent reduction in steam flow to the operating piston causes the pressure there to be reduced, through the hole shown in the piston. This reduction in pressure allows the governor valve to be closed by the spring shown in the base of the valve. If all elements of the governor are properly adjusted these changes in position of the valve occur so rapidly that the valve maintains an apparently fixed opening delivering an apparently constant steam pressure to the turbine. This is reflected in what appears to be a constant discharge pressure. In view of the change in discharge pressure which accompanies a change in capacity requirement it is easy to see that an increase in capacity (with its consequent decrease in pressure) will cause the governor valve to be adjusted to a wider average opening, and a decrease in capacity will reduce the opening. These changes in volume of steam flow to the turbine will speed up or slow down the pump to restore the pressure to normal at the new capacity.

(c) Adjustments.-The major adjustment which is made to the governor is adjustment of the force of the spring which works in opposition to the force of water pressure on the diaphragms. Increasing the tension of this spring will, by requiring an increase in water pressure needed to balance it, cause the pump discharge pressure to be increased. Conversely a reduction in the spring tension will



THE FOSTER PRESSURE REGULATING VALVE
FIG. 22

cause a reduction in discharge pressure. This adjustment is made through an adjusting screw at the top of the valve. The adjusting nut (fig. 22) makes a highly important adjustment to the governor. An inspection of the illustration will show that turning this nut will cause the diaphragm assembly to be raised or lowered, allowing the diaphragms to be adjusted to their most advantageous operating position. Experience has shown that, in general, the best position is obtained when, with the adjusting spring backed off completely, the pilot valve is open sufficiently to cause admission of from 50 to 75 p.s.i. of steam to the pump turbine. This adjustment should be made either with the adjusting spring backed off fully or with full operating pressure on the unit. The needle valve shown in the illustration is used to make the third adjustment to the governor. This valve allows steam to bleed from the outlet side of the pilot valve into the governor valve discharge. Bleeding away this

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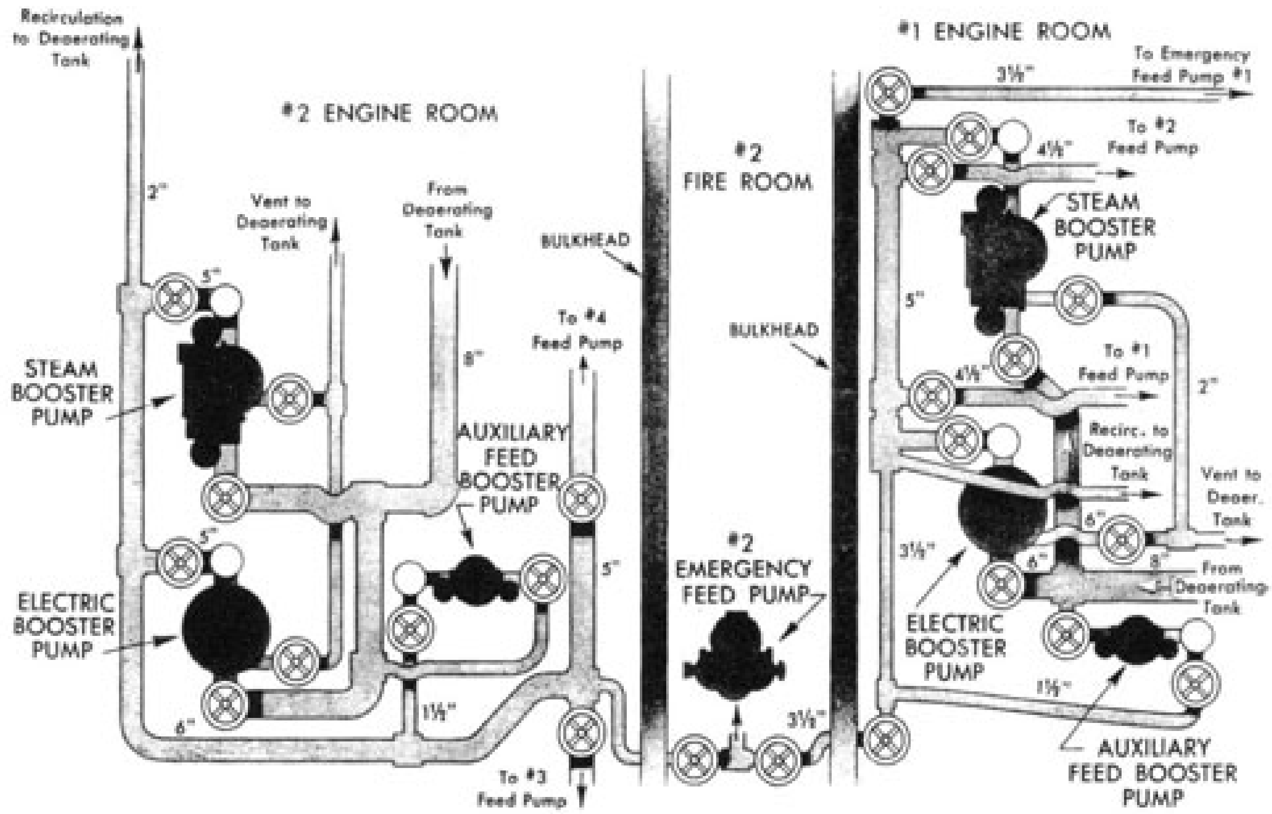

BOOSTER PUMP SUCTION AND DISCHARGE
FIG. 23

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small amount of steam reduces the size of the changes in steam pressure on the operating piston and reduces the amplitude of the oscillations of the governor valve. This prevents the governor from "hunting" or delivering a varying pressure. In general, it has been found that from one-half to three-quarters of a turn, open, will be a proper adjustment of the needle valve. However, experimentation with each valve may be necessary to establish the best adjustment. Attached to the base of the governor is a stem which, working in a yoke on the governor valve, is capable of manually pulling the valve open thus effectively bypassing it and making it necessary to control the pump speed with the throttle valve. The pump should always be warmed up with the

into each pump is a gate valve. The main pumps discharge through a vertical check valve and another gate valve into a 4 1/2" riser which leads into a common 5" discharge line. From this 5" line are led the two 4 1/2" main feed pump suction lines, with a gate valve in each to serve as the main feed pump suction valves. Passing to starboard, the 5" line reduces to 3 1/2" and, passing through a gate valve, leads aft, where it finally joins with the after system to provide the cross-connection line between the two. Leading to port from the 5" main line, another 3 1/2" line runs through a gate valve and then leads forward to the suction manifold of the No. 1 emergency feed pump in the forward fireroom, thus providing the hot suction line for that pump. For each booster pump suction casing a 2" line leads

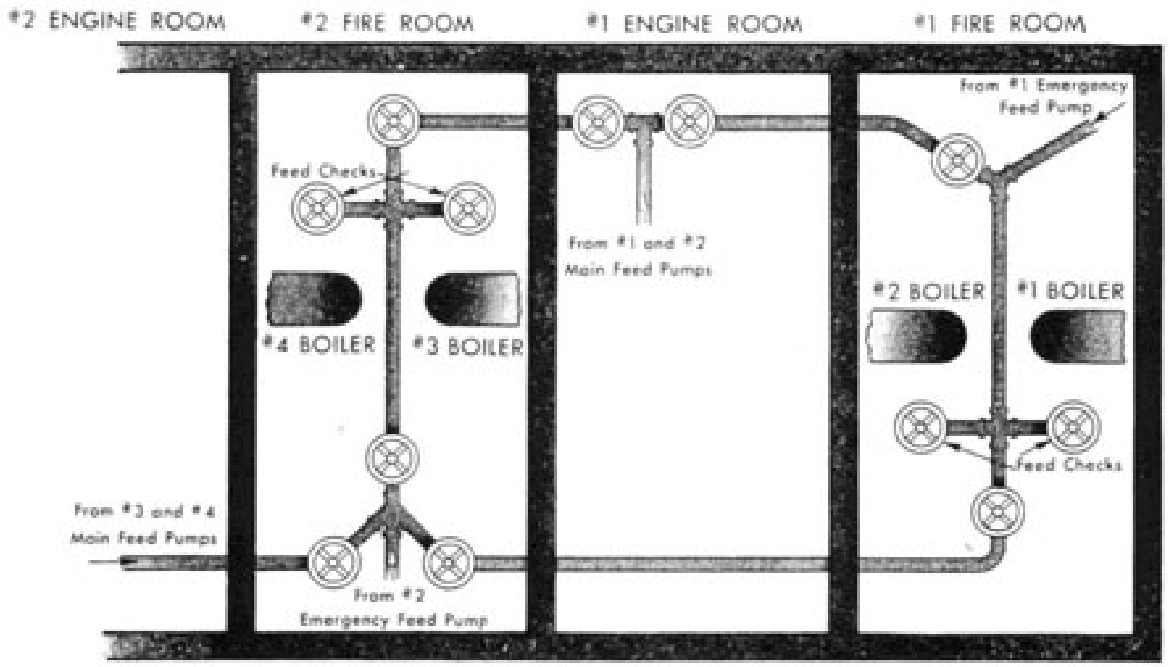
governor bypassed, and the governor put into operation when the pump is ready to go on the line.

(d) Notes.-The short life of the two-ply adnic metal bellows enforced the substitution of monel (stamped "Monel Anneal" on the slotted bellows head to identify it). A recent change in the General Specifications for Machinery (subsec. S47-6) precludes the use of bellows in the pump governors, therefore the Foster type 38P5 governor has been removed from the list of Acceptable Material.

5. FEED BOOSTER SYSTEM PIPING

(a) General Discussion.-Though the feed booster system is actually a part of the main feed system, it can best be treated as a separate system. In this system water is taken from the base of the deaerating tank and discharged to the suction of the main feed pumps. The machinery included consists of two main feed booster pumps, both steam-driven or one steam-driven and one electrically driven, and one electrically driven auxiliary feed booster pump. The auxiliary feed booster pump is very similar in design to the main pumps but is considerably smaller. The discussion of piping which follows in detail is of the forward system. Later, differences between the two systems will be discussed.

(b) Piping.-All three of these pumps take suction directly from the deaerating tank where the water temperature will be normally from 225 degrees to 250 degrees F. The main pump suctions lead through and 8" line which branches into two 6" lines, one leading to each pump. The auxiliary pump takes its suction directly from the base of the deaerating tank through a 3 1/2" line. The suction valve leading back to the deaerating tank to serve as a vent from that pump, with a valve located at each pump. From the 5" main line, a 2" recirculating line leads also back into the deaerating tank and discharges into the tank at a point which is above the conical baffle, so that water recirculating through the line must pass the steam control valve and there be deaerated. Around the 2" valve, located in this line, is installed the previously-noted 3/4" bypass. This bypass provides for reduced recirculation of the main feed booster pump when warming up the main feed pump or when discharging to the emergency feed pumps and it also provides a small recirculating line for use by the auxiliary feed booster pump. In general, the after system is arranged similarly to the forward system but the common discharge line from the main feed booster pumps is here a 6" line and leads to starboard and forward through the engine room up to the main feed pumps. The reason for the increase in size of this line is due to the further distance the water must travel before reaching the main feed pump suctions. Branches lead to the main feed pump suctions from this line and beyond these branches, the main line continues forward as a 3 1/2" line. Passing into the after fireroom, this line joins the cross-connection leading from the forward engineroom. Above the No. 2 emergency feed pump in the after fireroom will be noted two cut-out valves. From between these two valves the hot suction line leads to the suction manifold of No. 2 emergency feed pump. By means of this cross-connection line it is apparent that any booster pump can discharge to any main feed pump or to



MAIN FEED SYSTEM
FIG. 24

either emergency feed pump. Note The piping sizes indicated apply to the DD445 class, however, the arrangement of piping for the DD692 class is similar.

(c) Operating Instructions.-When warming-up in an engine room which has been secured, and thereby has a cold deaerating tank, it is necessary to recirculate water from the main feed booster pump back through the deaerating tank for at least half an hour before feeding to the boilers. In the case of a cold tank the feed water has been standing in the base of the tank with air above it and has consequently absorbed some of this air. To prevent the discharge of this air into the boilers the above operation is necessary to deaerate all this idle water. Whenever it is necessary to have more than one main feed pump in operation in each engineroom it is also essential that both main feed booster pumps be in operation. The full capacity of each main feed booster pump is only slightly more than that of each main feed pump that required for the main feed pump suction, consequently causing damage to the main feed pump.

6. MAIN FEED PIPING

(a) General Discussion.-The accompanying drawing of the main feed system has been simplified to show only those valves used in casualty control. This means the elimination of the pump discharge valves. This main feed system is as flexible and simple a system as could possibly be desired. A later discussion will show that except in two specific points no single casualty to the main feed line could cause the need to permanently secure any boiler and in no case would speed have to be reduced below half power.

(b) Piping System.-The loop shown passes through three of the engineering spaces only. The connection from the after engineroom consists only of the pump discharge line which joins the loop on the starboard side of the after fireroom. The discharge line from the forward pumps enters the loop on the port side, aft, of the forward engineroom There is in each fireroom a

and, therefore, if two main feed pumps were operating and only one main feed booster pump, the capacity of the two main feed pumps could easily surpass that of the single booster pump. This would cause a reduction in the booster pump discharge pressure below cutout valve on both sides of the loop which will allow water to flow to the feed checks, in that fireroom. from either side. In the after fireroom, a group of three

valves will he noted. One of these cuts out feed from the after pumps. The center of these three valves cuts out feed from the starboard side. The forward of these. three valves is the cut-out valve for the starboard leg of the feed loop. The discharge line from the forward main feed pumps enters the loop between two cut-out valves which allow water to be led either forward or aft. Since this feed system is not provided with auxiliary feed checks, the emergency feed pumps discharge directly into the main feed line, the forward pump leading in between the port cut-out valve in the No. 1 fireroom and the feed checks. The after emergency feed pump leads into the loop before the cut-out valve on the starboard side but between the other two valves, the presence of these other two valves making it possible for the emergency feed pump to discharge to the after boilers without going into the rest of the feed line. A thorough inspection of this piping system will show that the only casualty that can cause any boilers to be entirely without feed must occur in that leg of the line which passes athwartship between the boilers. Casually in any other part of the system may reduce the feed available to half capacity but all four boilers can at least be fed. In some instances full capacity may be maintained by paralleling the four pumps. In this case, however, it would then become necessary to operate the entire plant in parallel to maintain the balance of the condensate.

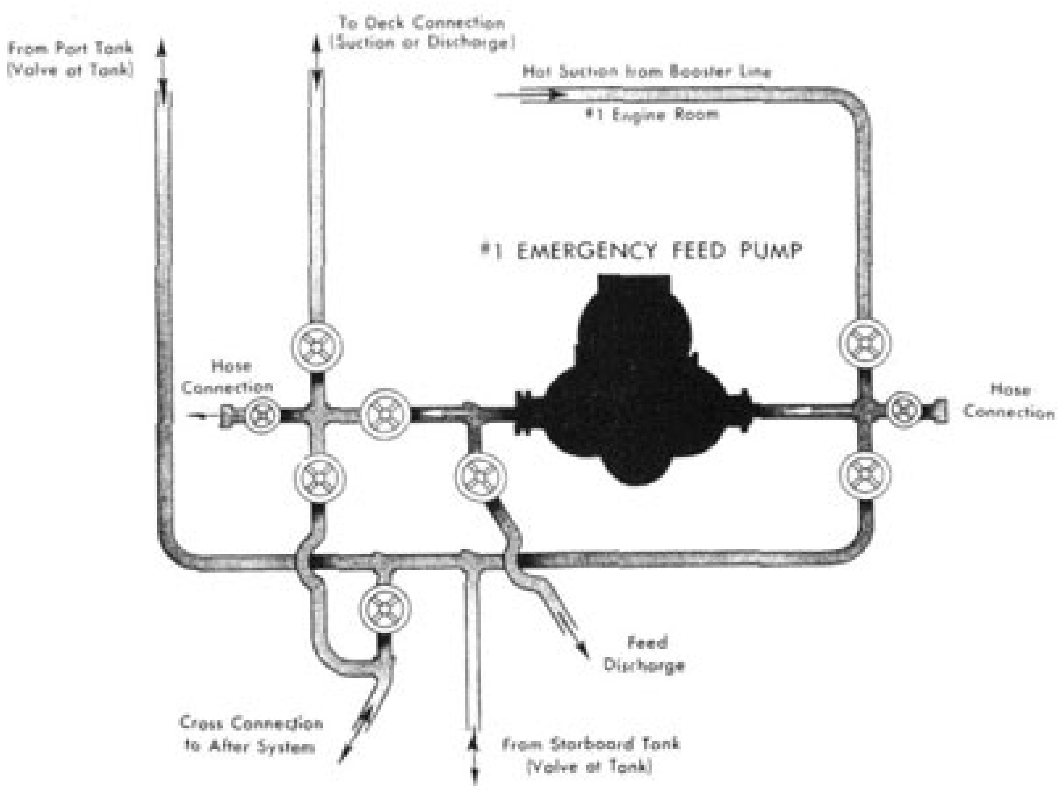
(c) Operating Instructions.-Since these plants up the starboard side of the ship. Any casualty occurring, then, to these empty sections of pipe will not affect operation of the plant at full power. Should a casualty occur in the discharge line from the after main feed pumps this will, of course, necessitate paralleling of the four boilers on the forward pumps but still allow parallel operation at half power. A casualty to the port leg of the loop leading into the forward fireroom would necessitate cutting out that leg but paralleling all four pumps through the after fireroom and feeding the forward fireroom from the starboard side would still allow parallel operation at full power.

7. EMERGENCY FEED PIPING

(a) General Discussion.-As previously noted, there is no separate system for feeding the boilers in emergency, since the discharge from the emergency feed pumps leads directly into the main feed line. However, a system is built up around the emergency feed pump which will provide for transferring feed water from one plant to another, will allow cold water to be discharged directly to the boilers or will allow for washing out boilers with fresh water and also provide a means of discharging water from the reserve feed tanks overboard or to another ship. The following discussion applies to the forward fireroom of the DD445 class destroyers. Differences between this and the after fireroom will be later noted, with the differences being apparent on figures 25 and 26. Figure 27 shows the arrangement in the DD692 class. The minor change shown here is not sufficiently important to warrant a separate discussion but will

are to be normally operated divided ("split-plant") the main feed system must also be divided. In doing this, it is required that pressure be kept away from as much of the feed line as possible, thereby reducing the area subject to casualty. This means that the valve leading aft from the forward pump discharge, and the port cut-out valve in the No. 2 fireroom be closed. This will allow water to be led forward from the forward pumps and will keep pressure away from that section of line between the forward engineroom and the after fireroom. The starboard leg should be lined up with the cutout valve which leads forward from No. 2 fireroom closed, and the starboard cut-out valve in No. 1 fireroom closed. If the other two valves on the starboard side of the after fireroom are open, we can then lead feed to the after boilers from the after main feed pumps and also keep pressure away from the long run of pipe leading also be noted.

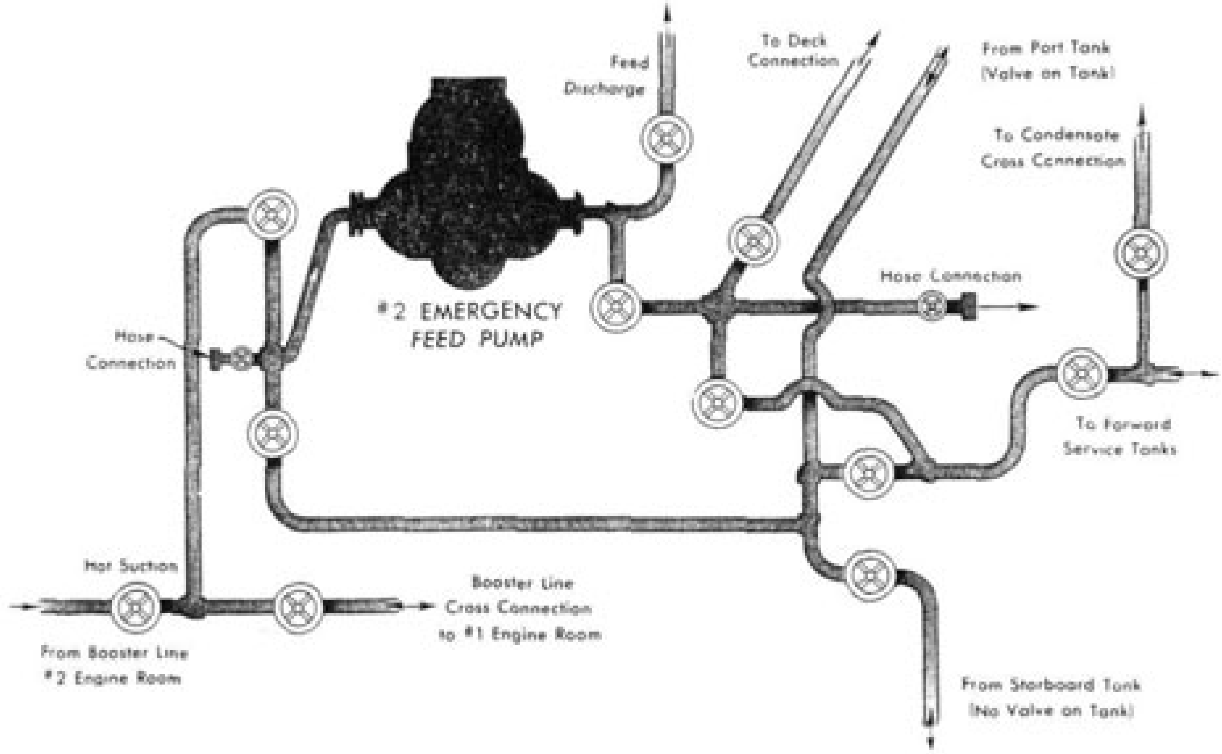
(b) Piping System.-The suction manifold of the emergency feed pump consists of two valves and a hose connection. One of these valves, as indicated in figure 25, is connected to the feed booster discharge line and provides for suction by the emergency feed pump from that line. This connection is called the hot suction line. The other valve is connected to a line which branches athwartship and leads to the two reserve feed tanks in this fireroom. At each tank a cut-out valve is provided. This will allow the emergency feed pump to take cold suction directly from either of the reserve feed tanks. The hose connection on this manifold can be hooked up any way it may be desired by using a portable hose. From the cold suction line a branch leads to starboard and then aft through the after engineroom and into the



EMERGENCY FEED SUCTIONS
#1 FIRE ROOM
FIG. 25

after fireroom. In this line there is a cut -out valve in the forward fireroom just after it leaves the cold Suction line. The discharge manifold on this pump is in reality two manifolds; one is a single valve which leads directly into the main feed line, the other ma be cut off from this single valve and is a low-pressure manifold being protected by a 100 p. s.i. relief valve. As shown on the sketch, one valve of the low pressure manifold leads up to a deck connection to provide the means for discharging water overboard from the reserve feed tanks. Another valve leads into the branch line previously mentioned on the outlet side of the cutout valve. Discharging through this last valve will allow us to pump water through this branch line and, since it joins with the after system, will allow that water to be pumped into the after system. A hose connection is also provided on this manifold. Arrangement of the after emergency feed piping is very similar. The hot suction connection, however, rises to the booster cross connection line in the fireroom between the two cut-out valves, as previously discussed in connection with the booster system. From the reserve feet! tanks suction lines lead to the cold suction valve of the manifold. From this suction line a branch also leads forward and joins with the branch leading from the forward system. In this line before leaving the fireroom there are provided two cut-out valves. The arrangement of the discharge manifold is the same as that. forward, with the low pressure manifold having one valve which leads between the two cutout valves in the cross-connection line. From this cross-connection line a 1-inch pipe leads overhead and, behind No. 3 boiler, joins the condensate cross-connection line. A valve is provided to cut out this line.

(c) Operating Instructions.-An analysis of this system shows that either emergency feed pump can take suction from either pair of reserve feed tanks and discharge into the main feed line. Either pump can take suction from its own pair



EMERGENCY FEED SUCTIONS
#2 FIRE ROOM
FIG. 26

of reserve feed tanks and discharge into the tanks of the other fireroom. Either pump can discharge into its own tanks only when taking suction from the booster line or from the suction hose connection. If pressure is placed upon the cross connection line, water can be led through the previously mentioned 1-inch line into the condensate cross connection for the purpose of filling either or both deaerating tanks. It should be especially noted that when transferring water from one pair of tanks to another the pump must be used which is in the space from which the water is to be taken. When the emergency feed pump is operating with its suction coming hot from the booster line the pump cylinder and valve chest become heated. As long as pressure on the booster line is maintained. water entering the pump will not flash into steam, but if it becomes necessary to shift to cold suction the heat in the pump and valve chest will, when the cold water enters under atmospheric pressure or less, cause it to flash into steam thereby vapor binding the pump. It may that it can take a cold suction. This shift should be necessary only when a casualty causes loss of the booster pressure and, since the main feed pumps are always used underway. could reasonably be expected to occur only on auxiliary watch. In this case, feed water could undoubtedly he delivered to the boilers in shorter time by starting the emergency feed pump in the other fireroom on cold suction. When underway, both hot and cold suction lines should always be open directly to the emergency feed pump manifold with only the manifold valves closed. If it is desired to keep the pump warmed up by allowing it to turn over very slowly this should be done with the cold suction valve open and not. the hot suction valve. The pump will then remain cold and if it is required to be put on the line the suction can be shifted from cold to hot without trouble. However, if the pump is turning over on the hot suction and the shift is necessitated by loss in booster pressure, causing securing of the main feed pumps, the shift to cold suction cannot be made in time to prevent a casualty.

take from 10 to 15 minutes to sufficiently cool the pump cylinder so

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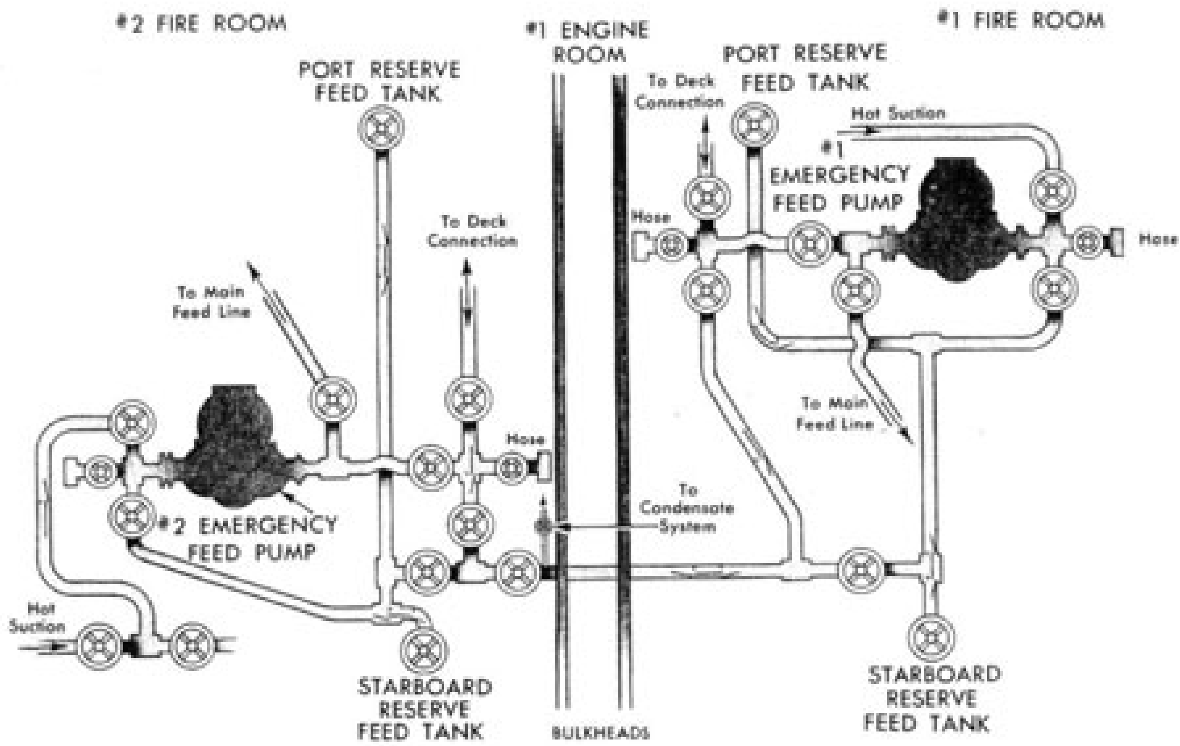

EMERGENCY FEED SYSTEM
692 - CLASS
FIG. 27

(d) DD692 Class.-The change in the emergency feed piping between the DD445 and DD692 class occurs in the forward fireroom only. Here the discharge from the low pressure manifold of No. 1 pump leads to the starboard side, there joining the cross-connection line as shown. The use of this arrangement has reduced somewhat the amount of piping required, while making it necessary to go to the starboard side to line up the cross connection into the forward reserve feed tanks.

8. FEED WATER LEVEL REGULATOR

(a) General Discussion.-This piece of equipment is being discussed after the main feed system although it is an integral part of that system. It is so closely related to the operation of the boilers check for each boiler and the economizer. In general, destroyers are fitted with two makes of feed water regulators although the earlier ships may have none installed. One is the Bailey regulator and the other the Swartwout regulator. The general arrangement and principle of operation of both these regulators is almost the same and, therefore, the discussion will be confined solely to the Bailey regulator.

(b) Operation.-This installation consists of a generator assembly, the regulating valve assembly and the connecting piping. The generator assembly is arranged with its connecting piping on the front of the steam drum as shown in figure 28. with the generator centered across the normal water level of the boiler. The regulating valve assembly is

that it is necessary to discuss it just before the boiler discussion. The purpose of this regulator is to vary the feed water discharge into the boiler in such a manner as to maintain a constant water level in the boiler. The valve in this unit is flanged directly into the main feed line between the feed connected with the valve itself in the main feed line and with its bellows attached to the generator by means of a length of copper tubing. The generator consists of two pipes, the internal pipe. which is connected, by the arrangement shown, to the gage glass fittings of the boiler, and an external

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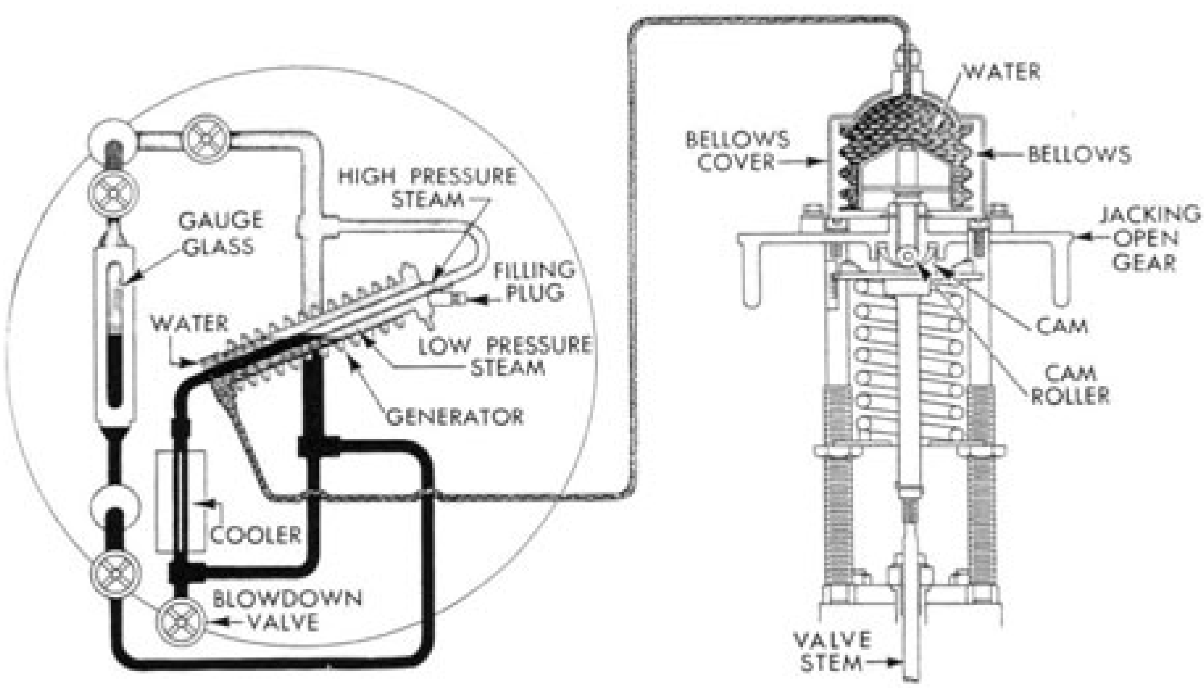
pipe which is connected to the valve bellow through the copper tubing. There is no connection between the internal and external pipes. Their inner spaces are entirely separate, with the internal piping running only through the outer pipe and the outer pipe welded at top and bottom to the inner pipe to hold it in place. When the valves from the gage glass fittings to the internal pipe are open, water will naturally rise in the internal pipe to the same level as that in the gage glass and will, in fact, reflect the water level in the boiler. Above this level the internal pipe with its connecting lines is full of steam. The generator or external pipe is, before being placed in operation, completely full of water as are the copper tubing and the bellows oft he valve assembly. This external system is entirely enclosed and the water is at atmospheric pressure before steam and water are allowed to enter the internal pipe. When steam and water enter the internal pipe the steam, being under high pressure, is at a high temperature. Heat will be transmitted from this steam through the internal pipe into the water surrounding it in the generator. Since the water in the generator is under atmospheric pressure this water will commence to form steam. As steam forms in the generator pressure will be built up in the generating system and this pressure, being transmitted through the copper tubing to the bellows, will cause expansion of the bellows. As is readily apparent in figure 28 the valve stem of the regulating valve is in contact with the cup which encloses the bottom of the bellows. Expansion of the bellows will cause this cup to be forced downward, pushing with it the valve stem, of some of the steam in the generator. This will naturally reduce the pressure in the generator, causing the bellows to contract and allowing the regulating valve to close. The instant steam begins to form in the generator pressure will also start to build up and if nothing opposed the expansion of the bellows, it would start to expand and open the regulating valve. If this were allowed the valve would be open, allowing feed to enter boiler with a very high water level in the boiler. In order to prevent this a spring, installed as shown in the sketch of the valve assembly, opposes the opening of the valve. The force of this spring is approximately 600 pounds which means that a pressure of approximately 45 p.s.i. must be built up in the generating system before the bellows can start to expand in opposition to this spring pressure. The point of water level at which 45 p.s.i. pressure is built up is about 3 inches above normal level. With the water level 3 inches below normal a pressure of about 60 p.s.i. will have been built up in the generating system. This is sufficient to force the regulating valve wide open. To sum this up, if the water level is 3 inches above normal, the valve is fully closed and if 3 inches below normal the valve is wide open.

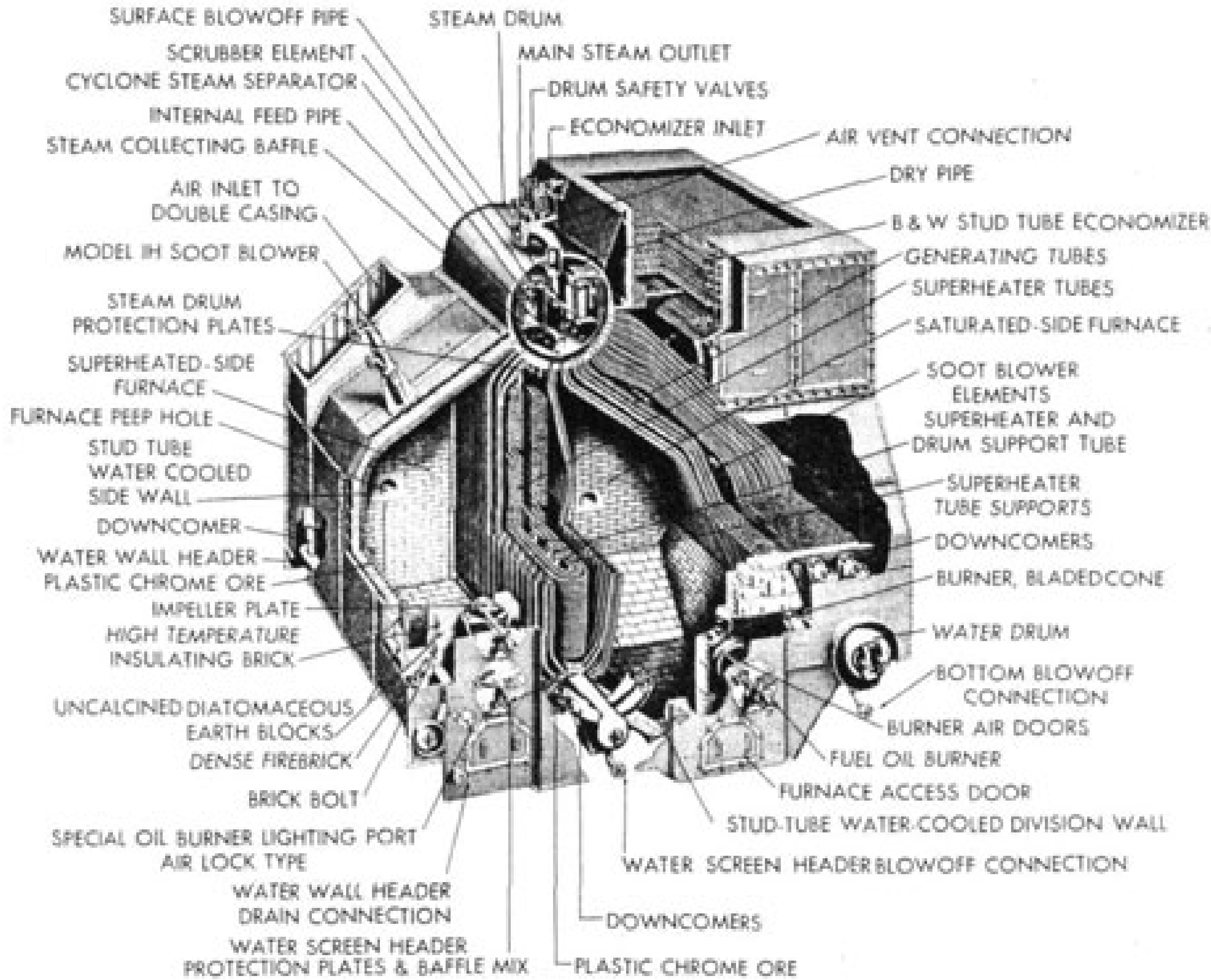
(c) Operating Instructions.- It should be especially noted that the spring force above mentioned is always tending to close the valve. This being the case, should anything happen to cause the generating system to reduce its pressure below 45 p.s.i., the valve will close entirely and cease feeding water to the boiler. This could occur through a leak in the generating system or through a puncture in the

thereby opening the regulating valve. With the unit in operation, if the level of water drops in the boiler the level of water in the inner pipe will also drop. There will be a greater area of the inner pipe full of steam. This will transmit more heat into the generating system, generate more steam and cause the pressure to rise. This rise in pressure will in turn cause the bellows to expand further and further open the regulating valve, thus allowing more water to enter the boiler to restore the level to normal. When the water level in the boiler rises we have a corresponding rise in water level in the inner pipe. The water which enters the inner pipe, due to this rise, has been standing in the cooler, located as shown on the sketch. This means that this water will be relatively cool, and on entering the internal pipe will cause condensation bellows or any part of the generating system. Because of this it *is essential that the check man be even more attentive to his gage glass than if he were feeding by hand*. It is apparent that a man on watch feeding by hand would, if he left the checks, leave them at least partly open even though this may be not quite sufficient for a normal feed. Under these circumstances it would take some time before the water level would drop out of sight. However if he were operating the feed water level regulator and the generating system were punctured while he was not watching the glass the valve would close off entirely and admit no feed whatever. Even at reasonably slow rates of steaming it would take only a very short time before water would be out of the glass entirely. The feed water level regulator is very effective when operating at constant speeds, but when

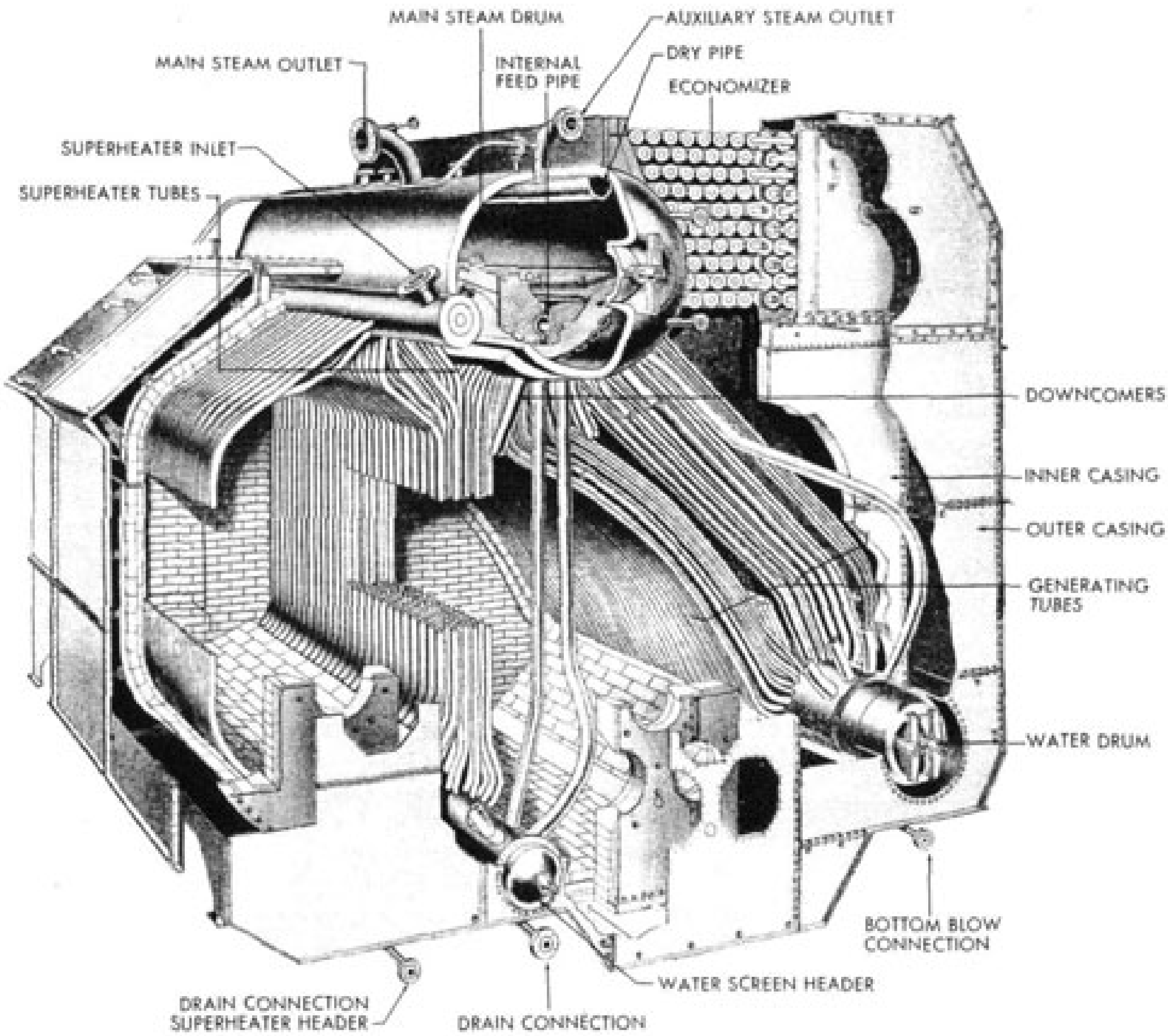


THE BAILEY FEED WATER LEVEL REGULATOR
FIG. 28

maneuvering will have a tendency to lag behind the change in steaming rate of the boiler. For a single maneuver it would maintain the water level very nicely but for more than one, it is apt to get so far behind that it is more desirable to shift to feeding by hand. However, the regulator should always be used in action since, should a casualty occur which would incapacitate the check man, the regulator will maintain water level in the boiler. Since the regulating valve is directly connected into the main feed line it must be fitted with some means to jack it open mechanically when it is desired to feed by hand. This is accomplished by means of a cam attached to the valve stem and a cam roller which is rotated by means of two levers. Operating the levers, the roller rises to the high point, of the cam and since the roller is allowed no vertical movement the cam is driven down carrying with it the valve stem and consequently opening wide the regulating valve. In figure 28 the arrangement of this cam and roller is shown. Under normal conditions if time water level in the boiler is held at a point which is higher than that desired it can be maintained at a lower point by bleeding steam pressure from the generating system when it is in operation. This will reduce the pressure in the generating system and allow less water than normal to be delivered to the boiler. If this is done pressure can be bled off without allowing air to enter the system. Should air enter this system a constant pressure could not be maintained. Therefore, it is essential that all air be excluded at all times from the generating system. Should the water level be carried at a point which is lower than that desired it can be most effectively raised by increasing the feed water pressure. Another method of varying the normal water level carried is by changing the tension of the spring in the valve assembly. This method is not very effective since the maximum change of water level obtainable will be about one-half inch only. The method of filling the generating system, outlined in the manufacturer's instruction book should be very carefully followed. The feed pressure recommended to cause best operation of the unit is about 775 p.s.i. At very high rates of feed the regulator will tend to carry a rather low level. In order to overcome this it is recommended that the feed pressure be carried as high as possible whenever boilers are operating at nearly full load.



BABCOCK & WILCOX SINGLE-UPTAKE
CONTROLLED-SUPERHEAT MARINE BOILER
FIG. 28A



FOSTER WHEELER CONTROLLED SUPERHEAT BOILER
Fig. 28B

Section VI

BOILERS

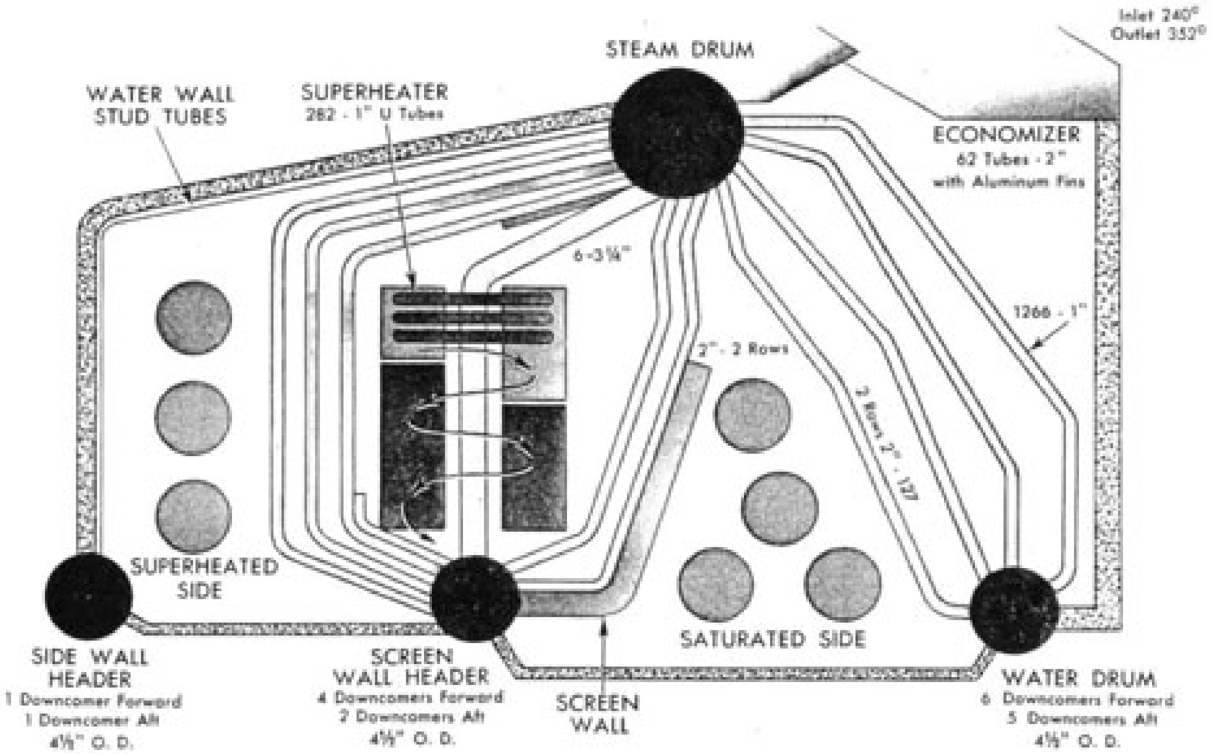
1. GENERAL DESCRIPTION

The boilers installed in both the DD445 and DD692 class destroyers can be termed superheat control boilers with enclosed draft. This means that the superheater is heated through firing of an entirely separate furnace from that which generates the steam. Enclosed draft means that air is delivered from the blowers to these boilers through a space which is between the inner and outer casings of the boiler. The fireroom, therefore, is under atmospheric pressure only. The maximum operating pressure of the boiler is 615 p.s.i. in the steam drum, and the maximum allowable temperature of the steam leaving the boiler is 850 degrees F. The presence of these two furnaces in the boiler permits the control of steam temperature through a range from that of saturated steam to 850 degrees F. total temperature. Four burners are installed in the saturated side of the furnace and three burners in the superheater side. By varying the relative firing rates of the two furnaces, the temperature of the steam finally discharged from the boiler may be controlled. The DD445 class destroyers have boilers of two different designs; i.e., the Babcock & Wilcox type boiler having a convection superheater, and the Foster Wheeler "GUEST" type boiler with a radiant superheater. DD472-481, 581-597, 649 and 662-665 have the Foster Wheeler "GUEST" type boilers, while all other vessels of this class have the Babcock & Wilcox type boilers. Figure 28A illustrates the general arrangement of No. 2 and No. 3 Babcock & Wilcox boilers, looking at them from the firing platform. The No. 1 and No. 4 boilers are built to the opposite hand, so that they are, reversed from this arrangement when looking from the firing platform. Figure 28B illustrates the general arrangement of the No. 2 and No. 3 Foster Wheeler boilers, looking from but a feed water heater. It is composed of sixty-two 2-inch **U**-tubes. Before entering the boiler the feed water flows through a myriad of passes through these 2-inch tubes, finally discharging into the boiler steam drum. Exhaust gases from the furnace of the boiler pass around these tubes and, in passing, transmit a portion of their heat through the tubes into the feed water. A series of aluminum fins is attached to the economizer tubes. These aluminum fins furnish an extended surface for the transfer of heat. The rise in temperature of the water in its passage through the economizer is approximately 100 degrees F.. which means that water leaving the deaerating tank at 240 degrees F. will enter the boiler at approximately 340 degrees F. This does away with the necessity for any feed heater in the system. The aluminum fins fitted to the economizer have a relatively low melting point and, therefore, must not be overheated. If there is no circulation of water through the economizer the heat collected from the exhaust gases will not be carried away by the water. This heat will then build up in the tubes and fins to the point where the fins will melt down. If the fins should melt, a baffle will be formed in the boiler uptake which may well be the cause of a flare-back into the fireroom. Therefore. while steaming the feeding of water into the steam drum should never be stopped completely, as this will stop the circulation of water through the economizer. If the water level becomes so high that this may appear to become necessary, it is far more advisable to blow the boiler down to reduce the water level than to shut off the feed water. When lighting off it is of course impossible to feed until the boiler is put on the line. To protect the economizer in this case no more than two burners, with the port-use sprayer plates, should be used to bring up the pressure. If any work has been done in the uptake of the boiler, it is desirable that an inspection of the economizer top be made before lighting off the boiler, since

the firing platform. The No. 1 and No. 4 are also to the opposite hand.

2. ECONOMIZERS (both types of boilers)

These boilers are fitted with a single uptake which is located above the saturated tube nest. In this uptake is installed the economizer. To all intents and purposes. this economizer is nothing some piece of metal may have been left resting in contact with the fins of the economizer. Should this be the case, the point of contact would be a point of concentrated heat which would cause the fins to overheat.



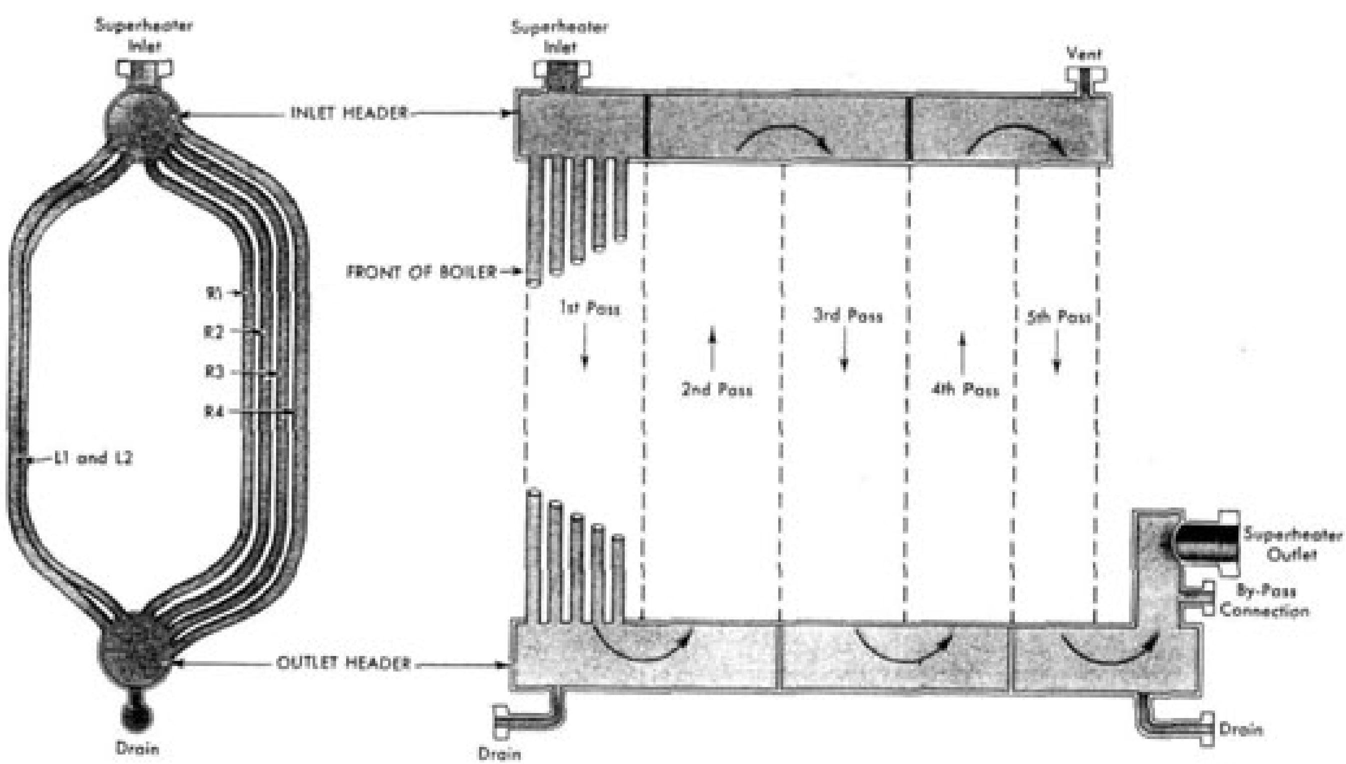
SCHEMATIC ARRANGEMENT
BABCOCK & WILCOX SUPERHEAT CONTROL BOILER
Fig. 29

3. GENERATING SIDE (B & W design)

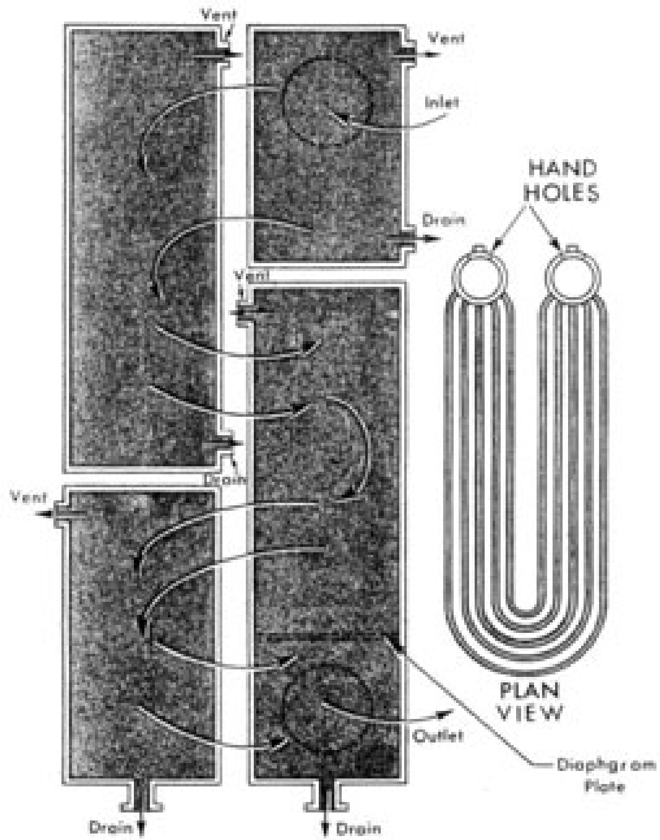
Between the steam drum and the. water drum (fig. 29) are installed the saturated side generating tubes. The two rows of tubes which are closest to the furnace are 2-inch tubes of which there are 127 in the 2 rows. These 2 rows, being in closest proximity to the fires in the furnace, receive more heat than any other and therefore require a greater volume of water to carry away this heat and take care of their resultant greater generation. The remaining 1,266 tubes in the saturated tube nests are 1-inch tubes arranged as shown. The total generating area of the saturated side is 4,002 square feet. These tubes are supplied with water by 4 1/2-inch downcomers which run from both ends of the steam drum to the water drum, between the inner and outer casings of the boiler. Six downcomers leach into the forward end of the water drum. and five downcomers lead into the after end. In the generating side of the boiler, water flow's through these downcomers into the water drum and circulates up through the generating tubes into the steam drums. Steam is formed by the conduction of heat from the furnace through the tubes. This mixture of steam and water entering the steam drum is treated there as described in the discussion on internal fittings, and finally leaves the steam drum as dry steam flowing into the superheater.

4. SUPERHEATER

(a) General Description (B & W design).-The superheater is composed of 282 1-inch "**U**" tubes which lead between four headers at the rear of the boiler, as shown on figure 30. These tubes extend to the front end of the boiler and are supported by being clipped to two superheater support tubes which run from the screen wall header to the steam drum. The headers are arranged as shown on the sketch of the superheater header arrangement to allow for four passes of the steam



SUPERHEATER HEADER ARRANGEMENT
(FOSTER WHEELER DESIGN)
FIG 29A

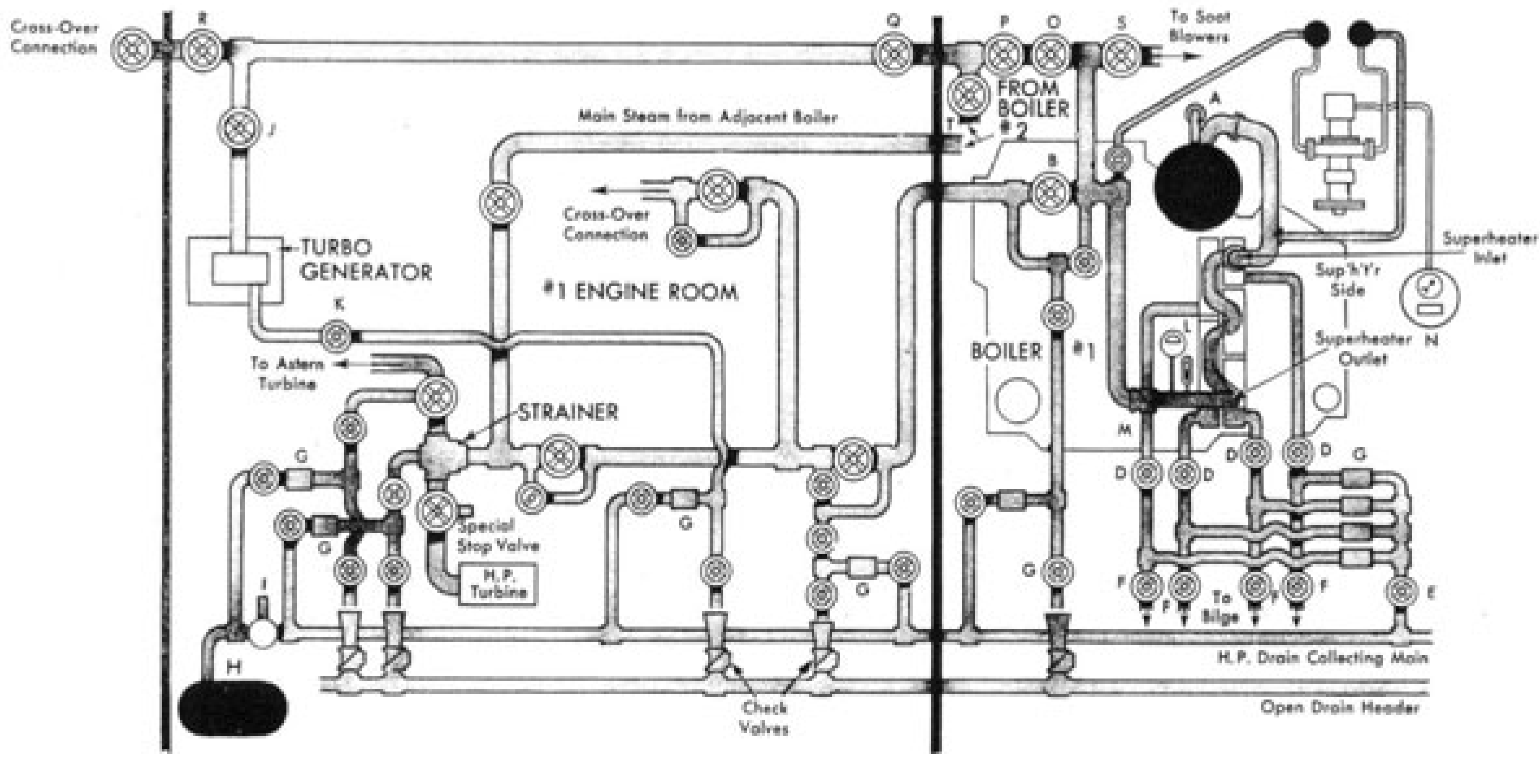


BABCOCK & WILCOX DESIGN
SUPERHEATER HEADER ARRANGEMENT
FIG. 30

through the superheater. The baffles for all but the last pass are formed by having separate headers, but that for the last pass is welded into the outlet header. Each header is fitted with both a vent and a drain. The drains discharge either to the atmosphere or into the high pressure drain system through a constant-flow trap. As previously mentioned, the superheater tubes are supported by two superheater support tubes. These are 3 1/4-inch tubes, and behind these two tubes are four more 3 1/4-inch tubes. These last four serve as steam drum support tubes. Extending from the screen wall header to the steam drum on each side of the superheater are two rows of 2-inch screen wall is built up on the right-hand row of tubes in the superheated side. This screen wail is formed of chrome ore plastic which is pounded into place about the tubes, being retained by metallic studs attached to the tubes. This screen wall extends only from the screen wall header to the top of the highest saturated burner. The opening between this wall and the steam drum is left to allow passage of gases from the superheater furnace through the saturated furnace and into the uptake. To the left of the superheater furnace a single raw of 2-inch tubes leads from the steam drum to the side wall header. This row of tubes is, with the exception of the tips of the studs, embedded in chrome ore plastic. This

generating tubes. To separate the saturated furnace from the superheater furnace, a furnishes the side wall of the superheater furnace.

BABCOCK & WILCOX BOILER INSTALLED IN DD 445 CLASS AND DD 692 CLASS DESTROYERS



A SATURATED STEAM CONNECTION AT STEAM DRUM
B MAIN STEAM STOP VALVE
C STRAINER DRAIN VALVE TO DRAIN HEADERS
D DRAIN VALVES AT SUPERHEATER HEADERS
E SUPERHEATER DRAIN TO H.P. DRAIN MAIN
F SUPERHEATER HEADER DRAINS TO BILGE
G IMPULSE TRAPS IN H.P. DRAIN LINES
H DEAERATING FEED WATER HEATER
I RELIEF VALVE IN H.P. DRAIN SET AT 40 LB. PER SQ. IN.
J TURBO-GENERATOR THROTTLE VALVE
K TURBO-GENERATOR STEAM CHEST DRAIN VALVE
L SUPERHEATER OUTLET STEAM TEMP. THERMOMETERS MERCURY AND DIAL
M HIGH SUPERHEATED STEAM TEMPERATURE ALARM ACTUATING BULB
N BAILEY SUPERHEATER PROTECTION DEVICE

DIAGRAMMATIC ARRANGEMENT SHOWING PORTION OF MAIN STEAM PIPING AND SUPERHEATER DRAINS
FIG. 30A

Small baffles of chrome ore are located as shown on the accompanying sketch. Under no circumstances should any burner in the boiler, either superheater or saturated, be lighted off unless the drains from the superheater headers are open, allowing steam to flow through the superheater. If this is not done, steam will not flow through the superheater to carry away the heat transmitted from the furnace. Heat from the saturated furnace will carry over into the superheated side and. therefore, it is necessary to do this when the saturated side is lighted off as well as when the superheated side is lighted off.

(b) General Description (Foster Wheeler design).-DD472-481, 581-597, 649, and 662-665 destroyers of the DD445 class have superheat control boilers with radiant superheaters. The radiant superheater is composed of one hundred and fifty six 1 1/2-inch O. D. bent tubes which lead between two headers. The fireside rows of superheater tubes, i. e.. rows L1, L2, R1, and R2 are of 18 percent chromium, 8 percent nickel, titanium stabilized alloy steel. There is butt welded to each end of the 18-8 tubes a 4- to 6-percent chrome tube end. These tube ends are necessary in order that tight rolled joints may be maintained after roiling the tubes into the 4- to 6-percent chrome headers. The remaining superheater tubes, i. e., rows R3 and R4, are of 4- to 6-percent chromium, 0.5-percent molybdenum, titanium alloy steel. However because of the development of circumferential cracks at the "knuckles" of the tubes, due to high coefficient of expansion of the "15-8" tubes, the Bureau has authorized the installation of 4- to 6-percent chrome replacement tubes. The tubes extend from the superheater inlet header at the top of the superheater furnace to the superheater outlet header at the bottom of the same superheater when the boiler stop valve (*B*) is closed, in order to make the steam flow through the superheater under the above condition, an orifice is installed in the auxiliary steam nozzle (ahead of the junction where the superheater bypass line joins the auxiliary steam line). Orifice plugs having a one-half-inch diameter hole in them are installed at the entrance of the R3 and R4 tubes in the first and second passes to increase the steam mass flow through the L1 and L2 tubes of these passes.

(c) Notes on Operation.-The Engineer Officer should thoroughly familiarize himself with all the latest Fleet and Bureau directives relative to superheat control, and instruct his watch officers and leading petty officers in carrying out their provisions. Nothing stated in the following paragraph should be construed as superseding such directives. When maneuvering at low rates, especially on four boilers, it is recommended that the superheater furnace not be lighted off and that the ship be operated on saturated steam, through the superheater. Under the frequent changes of speed necessary in this condition it will not be possible to maintain any sort of constant superheat and, therefore, not only will the economy of operation be less but the chance of damaging the superheater will be greater. However, operation of the turbo-generators will provide an appreciable flow through the superheater. With two boilers in operation it should not be necessary to secure the superheater when a stop bell is received, as this flow will provide protection for the superheater. No superheater should be lighted off unless by direct order from the control engineroom. If carrying superheat when an astern bell is received the steam temperature should not be reduced.

(d) Superheater Operation (Babcock and Wilcox boiler)

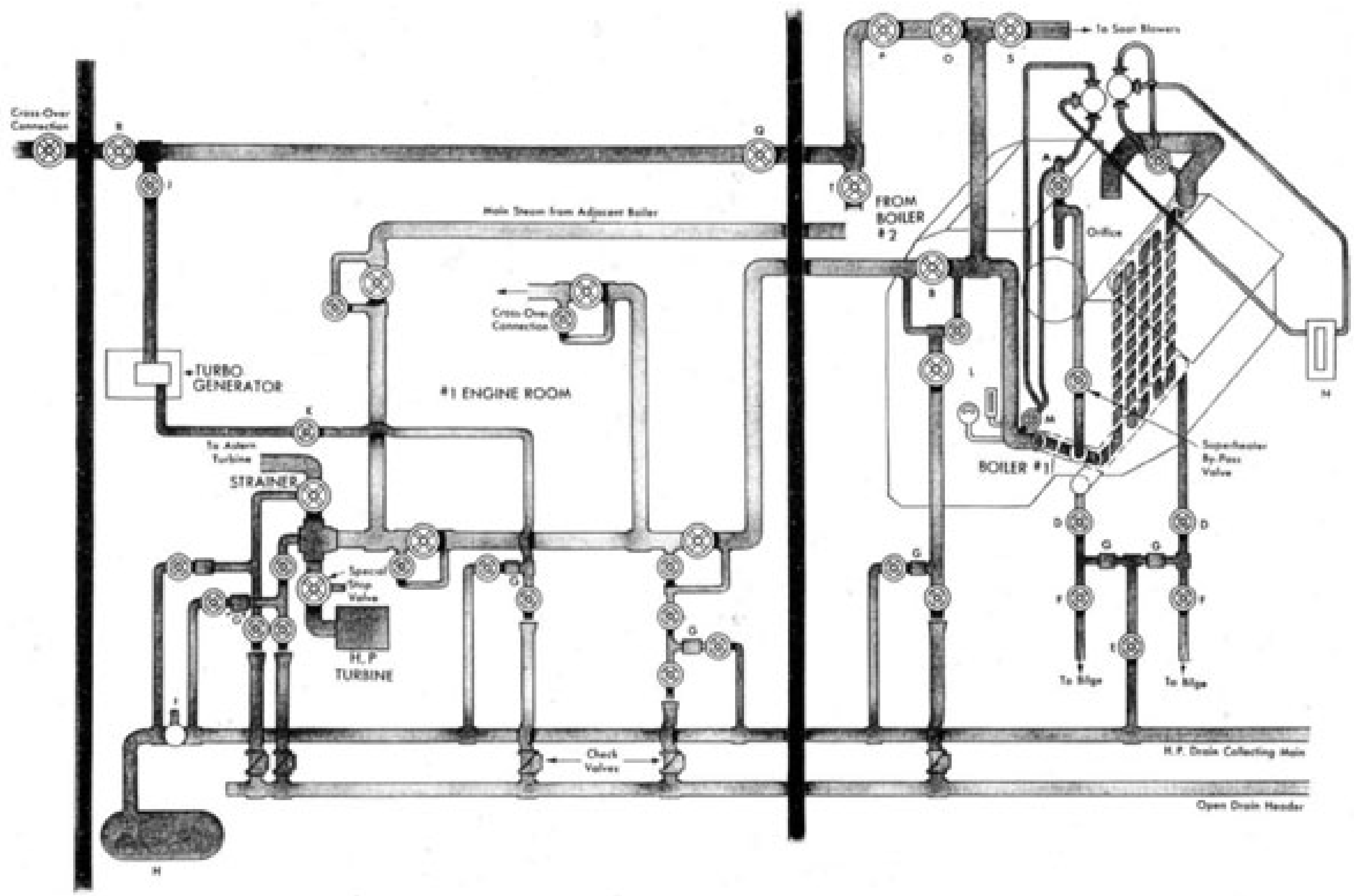
(1) SAFETY PRECAUTIONS

furnace. Diaphragms are installed inside both superheater headers to allow five passes of the steam through the superheater. The superheater inlet header is fitted with a vent, while the superheater outlet header is fitted with two drain connections. The drains discharge either to the atmosphere (bilge) or into the high-pressure drain system through a constant-flow impulse trap. The superheater outlet header is supported from two slotted lugs, which allows for vertical, expansion of the tubes. The superheater outlet header is supported by saddles mounted on the boiler foundation. A superheater bypass line is installed between the superheater outlet and the auxiliary steam line to induce flow through the

(*a*) When a boiler unit is first fired with the superheater side in use, set high-temperature alarm to sound at approximately 860 degrees F., and check *frequently* for proper operation. This alarm must be maintained in proper operating condition at *all times*.

(*b*) When steaming a boiler unit with the superheater side in use, the thermometers at superheater outlet (both the mercury and dial type) should be in place and reading correctly. If at any time there is any reason to believe these thermometers are not reading correctly, they should he immediately checked, and replaced if necessary.

FOSTER WHEELER BOILER INSTALLED IN DD 445 CLASS DESTROYERS



A SATURATED STEAM CONNECTION AT STEAM DRUM
B MAIN STEAM STOP VALVE
C STRAINER DRAIN VALVE TO DRAIN HEADERS
D DRAIN VALVES AT SUPERHEATER HEADERS
E SUPERHEATER DRAIN TO H.P. DRAIN MAIN
F SUPERHEATER HEADER DRAINS TO BILGE
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H DEAERATING FEED WATER HEATER
I RELIEF VALVE IN H.P. DRAIN SET AT 40 LB. PER SQ. IN.
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L SUPERHEATER OUTLET STEAM TEMP. THERMOMETERS MERCURY AND DIAL
M HIGH SUPERHEATED STEAM TEMPERATURE ALARM ACTUATING BULB
N BAILEY SUPERHEATER PROTECTION DEVICE

DIAGRAMMATIC ARRANGEMENT SHOWING PORTION OF MAIN STEAM PIPING AND SUPERHEATER DRAINS
FIG 30B

(*c*) Keep steam pressure and temperature under constant observation. When the high-temperature alarm sounds, immediately reduce the firing rate under the superheater side until the steam temperature drops back to normal.

(*d*) Never keep a lighted burner in use under the superheater side of a boiler unit unless the superheater protection device indicates at least 2.0 inches of water pressure differential across the superheater.

(*e*) When there is no steam flow through the super-heater, that is, when all of the steam taken from the unit is from the auxiliary steam connection, a steaming rate of 15,000 pounds of saturated steam per hour per boiler (equivalent to a firing rate of approximately 1,000 pounds per hour per boiler) must not be exceeded except in an emergency.

(*e*) Never light a burner in the superheater side furnace when the pointer is in the red zone, i. e., less than 2.0 inches of water, as this indicates insufficient Steam is flowing through the superheater.

(*d*) When starting up a cold boiler, open both the superheater header drain valves to the bilge (*D*) & (*F*) and valve in superheater bypass line. As soon as boiler pressure exceeds that in the high pressure drain system, superheater drain valve (*E*) to high pressure drain main should be opened wide and bilge valves (*F*) closed. The superheater bypass valve should remain in the open position as long as the boiler is fired with the superheater outlet stop valve secured. When the superheater stop valve is opened, the superheater bypass valve should be secured. However, if superheater side burners are lighted off and a sudden reduction in speed or stop bell may be expected, the superheater bypass valve should be opened. At speeds above 20

(*f*) Fireroom and engineroom personnel should become thoroughly acquainted with boiler construction, arrangement of main and auxiliary steam lines, location of valves and drains, and with the procedure as outlined below, so that in an emergency prompt and proper action can be taken. If in doubt on any of these items, ask questians.

(*g*) The proper handling of a superheat-control boiler requires the closest cooperation between fire-room and engineroom personnel, if damage to the boiler, superheater, and/or the main steam line and turbine is to be avoided. Wherever these instructions require the opening or closing of valves or drains in the engineroom, the fireroom personnel should make sure that such operations have been accomplished be-fore proceeding with subsequent operations in the fire-room. If, for any reason, it becomes necessary to close a steam line valve in the engineroom while the plant is in operation, the engineroom personnel must inform the fireroom personnel of such action, in order that the burners on the superheater side can be secured and damage to the superheater prevented.

(*h*) The primary object of these instructions is to familiarize the fireroom and engineroom personnel with the proper procedure for placing in service, maintaining, and removing from service the super-heater side of the boiler.

(e) Superheater Operation, Foster Wheeler Boiler.

knots the flow through the superheater bypass line will be reversed, causing a decrease in steam temperature of approximately 5 degrees-10 degrees.

(*e*) When there is a change in the steaming rate for any reason, immediately vary the oil flow to the superheater burners, either by operating the micrometer valve or by cutting in or out burners so as to carry the designated steam temperature. It is very important that the amount of oil fired (superheater side oil pressure) be changed gradually to prevent overheating of tubes in localized areas.

(*f*) Superheater bypass valve shall *always* be in the open position when an oil burner (s) is in use, with the main steam stop valve (*B*) secured.

(*g*) Superheater side oil burners should never be operated with the air registers more than one-half closed. Closing the air registers beyond this point causes the flame to impinge on the superheater tubes, resulting in overheated tubes.

(*h*) At very low rates of boiler operation with the superheater side in use, several small size sprayer plates should be employed on the saturated side in lieu of one large size plate in order to reduce the air pressure required. By lowering the air pressure at this rate, flame mushrooming and white smoke in the superheater side furnace is reduced if not prevented.

5. BOILER OPERATION

(1) SAFETY PRECAUTIONS:

(*a*) See paragraphs 4. (d), (1) (a) through 4. (d), (1) (d) ; and 4. (d), (1) (f) through 4. (d), (1) (a), above.

(*b*) Preparatory to lighting off a boiler, check to insure that the root valves in the connecting piping to the bead chambers are in the wide open position. The dividing line between the green and red zones oil the dial should be set at 2.0 inches of water mark on the graduated scale. When the pointer of the super-heater protection device indicates a pressure differential of 2.0 inches of water, the steam flow through the superheater is approximately 5,600 pounds per hour. If the steam flow through the superheater is less than 5,600 pounds per hour, the pointer on the superheater protection device will be in the red zone.

(Refer to fig. 30A for Babcock and Wilcox boiler, and fig. 30B for Foster Wheeler boiler)

(a) Starting One Boiler From Cold Condition.-Assume the machinery plant is being started up from a cold condition, and the first boiler is being lighted: All superheater drains (*D*) and (*F*) to the bilges should be opened wide, and superheater drain (*E*) to the high pressure drain system should be closed.

(1) Bring the unit up to pressure with only the saturated side in use by following the procedure out-lined in the boiler instruction book for DD445 class and DD692 class destroyers. Steam taken from the auxiliary steam connection (*A*) on the boiler drum will then be available for auxiliaries operated with saturated steam.

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(2) Check the air registers of all oil burners on the superheater side, to assure that the doors are tightly closed.

(3) Check all main steam and turbo-generator steam stop valves to assure they are dosed.

(4) While bringing the unit up to pressure, open bypasses around the boiler stop valve (*B*) and other main steam line valves between the boiler stop valve and main engine to be warmed up. Crack valves (*O*), (*P*), (*Q*), and (*J*) in line leading from boiler to turbo-generator; open all drains on both steam lines to open drain header. This will permit a superheater outlet, which can be kept under observation by watching the gage and thermometers provided for this purpose.

(9) When the boiler is first fired with the super-heater side in use, the high temperature alarm (*M*) should be adjusted to sound at approximately 860 degrees F. *As a safety precaution, it is important that this alarm be properly set and maintained in good working order at all times.*

(10) The air register doors of those burners on the superheater side which are not actually in service should be retained in the closed position.

gradual warming up of the piping as the steam pressure is being raised.

(5) When the steam pressure in the boiler and steam lines exceeds that in the high-pressure drain system, all drains leading into the high-pressure drain collecting main should be opened and all valves leading to bilge (*F*) and to the open drain header should be closed. The high-pressure drain header leading to the deaerating heater (*H*) is fitted with a relief valve (*I*) set at 40 p.s.i, pressure. It is therefore important that the impulse traps be periodically checked to assure that they do not stick in the open position. After the boiler pressure is in excess of the relief-valve setting, the popping of this valve may be an indication that one or more traps are stuck in the open position.

(6) As soon as the boiler pressure has been built up to approximately 500 p.s.i. with only the saturated side in use, slowly open stop valves (*O*), (*P*), and (*Q*) in the steam line leading to the generator turbine throttle valve (*J*). Drain all condensate and, using saturated steam, proceed to place the generator in service in accordance with the turbogenerator instruction book.

(7) This will establish a steam flow through the superheater. The superheater protection device (*N*) will register the amount of steam Hawing through the superheater by measuring the pressure differential across the superheater. When the flow of steam is in excess of 5,000 pounds per hour in (B & W) boilers or 5,600 pounds per hour in (F. W.) boilers, or 2.0" of water pressure differential, the instruction sign on the Bailey superheater

(11) Up to the time of actually firing the super-heater side, the superheater can be considered as a portion of the main steam piping which extends from the boiler drum to the generator being placed in service.

(b) Putting Unit on Line When One or More Boilers Are Supplying Superheated Steam.

(1) NORMAL OPERATING PROCEDURE-SUFFICIENT TIME AVAILABLE:

(*a*) Bring the additional unit up to line pressure by firing under the saturated side only, following the procedure outlined in the Boiler Instruction Book for these ships.

(*b*) On the boiler or boilers in service supplying steam to the main steam line and turbo-generator to which the incoming boiler is to be cut in, gradually reduce the firing rate on the superheater side at a rate not to exceed 50 degrees F. every five minutes until the steam temperature has been reduced to approximately 600 degrees F. at the superheater outlet. Be sure that all air register doors of the burners on the superheater side and those not lighted off on the saturated side are in the fully closed position.

(*c*) Prior to cutting in the additional boiler, be sure that the auxiliary steam line has been thoroughly warmed,

BEFORE ANY BOILER IS CUT IN ON THE MAIN STEAM LINE. IT SHOULD FIRST BE CUT IN ON THE SATURATED STEAM LINE. IN ADDITION, ANY COMBINATION OF BOILERS CONNECTED TO A COMMON MAIN STEAM LINE MUST

protection device "Secure Burners" will not be illuminated, while the pointer on the Yarnall-Waring instrument will be in the green zone. In the event tile pressure differential as shown by the superheater protection device falls below 2.0", all superheater side oil burners should be secured.

(8) Increase the steam flow through the super-heater by loading turbogenerator and warming main engine until the superheater protection device registers a pressure drop of 2 or more inches of water. With this condition met, the superheater side can now be placed in service by lighting off the first burner (identified by the (*A*) on the boiler front) under this side of the boiler. This burner should be fitted with the smallest size sprayer plate (5015F) available. The firing rate under both the saturated and superheater sides should then be regulated to maintain the desired steam pressure and the temperature at the

ALSO BE CONNECTED TO A COMMON AUXILIARY STEAM LINE.

Before cutting in the additional boiler, be sure that the piping leading from this boiler to the steam piping which is filled with superheated steam from the other boilers is properly warmed up and that this piping lead has been thoroughly drained.

(*d*) With the incoming boiler pressure 5 to 10 p.s.i. higher than the superheated steam line pressure, proceed to cut in the boiler under saturated steam conditions by cracking the main steam stop valve and allowing pressures to equalize, then slowly open the superheater outlet valve wide.

(*e*) When the steam flow through the superheater is sufficient to produce a pressure drop through the superheater equal to or greater than 2.0 inches of water as shown by the Superheater Protection Device (*N*), the first superheater side burner *A* may be

lit off. A lighted torch should be passed through the special lighting-off tube provided for this purpose. This lighting-off tube is constructed on the principle of an air lock. The torch is first introduced through the shutter at the outer front plate. This shutter is then closed and the shutter at inner front plate opened. The torch can then be introduced into the furnace and held so that the flame from it will be in the line of the oil spray. The valves between the oil header and the burner should then be opened, the last one gradually. The air-register doors should be kept closed until ignition occurs, following which they should be

(*c*) When operating with the saturated side only in use, both before and after cutting in on the main steam line, air leakage through the superheater furnace must be reduced to a minimum by keeping the air registers on the superheater side tightly closed and by operating the boiler with as low an air pressure as operating conditions permit (approximately 0.5 of an inch of water air pressure or less).

(*d*) Warm up the auxiliary steam line and open the auxiliary stop valve as described under "Normal Operating Procedure."

regulated to maintain ignition. After the burner has ignited, pull the torch back into the tube, close shutter at the inner front plate, open shutter at the outer front plate and remove the torch. This construction permits lighting a burner on the superheater side even though a high air pressure prevails in the double front. It prevents the torch flame from being blown out or being blown back, and possibly causing injury to the operator. In lighting-off the remaining burners on the superheater side the air doors should be kept fully closed while each burner in turn is being lighted.

(*f*) Steam temperature on the incoming boiler should be raised to 600 degrees F. at the superheater outlet. The steam temperature on all boilers should then be raised to approximately 850 degrees F. at a rate not to exceed 50 degrees F. every 5 minutes.

(*g*) When the ship is operating under ahead conditions, the steam temperature should be carried at approximately, but not in excess of, 850 degrees F. When operating under astern conditions, the steam temperature should be reduced to approximately 700 degrees F. Every care should be exercised to keep the steam temperatures within these limits whenever the boiler is on the line. When operating under steady conditions, the steam temperature at the superheater outlet should be held constant, and .when necessary to change this temperature it should be done gradually, to avoid opening rolled or gasketed joints in the superheated steam system.

(2) EMERGENCY PROCEDURE-TIME LIMITED: When it is necessary to cut in

(*a*) With the pressure on the boiler to be cut In at least 10 p.s.i. higher than line pressure prior to cutting in, slowly open the superheater outlet stop valve to the wide open position.

(*f*) When lighting off the superheater side after steam flow through the superheater has been established equal to or greater than a pressure drop through the superheater of 2.0 inches of water pressure as indicated on the Superheater Protection Device (*N*), care should be taken that a minimum amount of air enters the furnace before the burner is actually lighted. Instructions to "purge the furnace" as contained in Chapter 51 of the Bureau of Ships Manual and in the Boiler Instruction Look shall not apply to the super-heater side furnace of superheat control boilers.

(*g*) With the boiler cut in on the auxiliary steam line and a steam flow through the superheater (a reading of 2.0 inches of water or more on the Superheater Protection Device), the first burner should be lighted off as described in paragraph 5 (*b*), 1 (*e*) above. The steam temperature on the cut-in boiler should then be raised to that being carried by the other boilers at a rate not to exceed 50 degrees F. every 5 minutes.

(3) CUTTING IN WITH SUPERHEATED STEAM-ADEQUATE STEAM FLOWING THROUGH THE SUPER-HEATER:

In the event that a steam flow through the Super-heater (main steam stop valve closed) can be established equal to or greater than that which will give a drop of 2.0 inches of water as indicated by the Super-heater Protection Device, the boiler may be cut in on the line with superheated

an additional boiler expeditiously, the boiler may be cut in "saturated" to the main steam line without reduction of the main steam line temperature provided the following precautions are adhered to:

(*a*) Bring the additional unit up to line pressure by firing under the saturated side only, following the procedure outlined in the Boiler Instruction Book for these ships.

(*b*) Insure all drains, (*D*) and (*F*), on all super-heater headers and superheater outlet valve are open and complete drainage of the superheater assured prior to cutting in on the twain steam line. Strict precautions on complete drainage are necessary under these conditions because any carryover of water may cause opening of flanged joints by the sudden cooling effect produced thereby. These drains should remain open to the high pressure drain main as long as the boiler is under steam at line pressure.

steam by following directions listed below. A study should be made of figure 30A or 30B. The operator should make himself thoroughly familiar with the drain arrangement as shown on this sketch, to assure himself that these instructions can he properly followed. To start the procedure, check:

(*a*) That the unit is up to line pressure.

(*b*) That all individual superheater header drain valves (*F*) to the bilge are closed.

(c) That valves (*D*) and (*E*) in the drain lines from each superheater header lone drain line per header), are open, permitting drainage into the high pressure drain main. It is important to note that impulse steam traps are located in the drain lines to the high pressure drain system, and that these traps should be kept in good working order. Then proceed as follows:

(*d*) Warm up the boiler outlet steam line; open by pass valves around the main steam stop valve and

crack open main steam stop valve (*B*). Bypasses can be opened up to, but not including, the last valve with line pressure on its far side. Open drains of line stop valves to the low pressure drain system.

(*e*) Valves in drain lines from each superheater header and superheater bypass line leading to the fresh water drain main or bilge should be opened the maximum amount possible without causing unbearable conditions in the

(*j*) After the boiler has been cut in, and steam flow through the superheater and steam line to a machinery unit using superheater) steam has been definitely established, all bypass valves and drains discharging either to the bilge or to the open header drain main can then be closed. The firing rate on the saturated and superheater sides should then be readjusted to maintain the desired steam pressure and temperature.

(c) Operation Under Steady Conditions.-While a

fireroom, in order to obtain tile maximum possible flow through the superheater.

(f) If opening the drains to the bilge, and to the high pressure and open header drain mains as specified above does not produce a steam How through the superheater equal to or greater than 2.0 inches of water on the superheater protection device, the steam flew through the superheater (assuming boiler No. 1 is being cut in, and No. 2 boiler is supplying steam to No. 1 engine room) can be increased by slowly ripening valve (*O*) and (*P*), and slowly closing valve (*T*); i.e., slowly transferring the turbogenerator steam load from the No. 2 boiler to the No. 1 boiler. If the No. 2 boiler is supplying superheated steam at approximately 800 degrees-825 degrees F., to a turbo-generator, the period of transition from No. 2 boiler to No. 1 boiler should be about fifteen minutes when the total load is shifted (steam temperature at turbo-generator is lowered from approximately 800 degrees to 490 degrees F,). Only enough load should be transferred to the No. 1 boiler as may he required to build up the flow to 5,000 pounds per hour in (B & W1 boiler's or 5,600 pounds per hour in (F. W.) boilers. If the steam temperature at turbo-generator is not dropped to saturation temperature, the time required to lower the steam temperature will be proportionately less, i.e., both No. 1 and No. 2 will be supplying steam to the turbo-generator.

(*g*) Light off the first burner on the superheater side, using a sprayer plate of the smallest size 5015F) at prevailing oil pressure.

boiler is being operated under steady steaming conditions with the superheater side in use. the superheater outlet steam gage and thermometers should he kept under constant observation. Any minor load change should be taken care of by manual readjustment of the oil pressure under the two sides of the unit, in order to maintain the desired steam pressure and temperature. This can be accomplished by means of the fuel-oil pressure regulating valves located in the fuel oil header lines leading to both the saturated and superheater sides of the boiler. *(d) Operation When Maneuvering.*

(1) Under maneuvering conditions and with the superheater side in use, it *is particularly important* to keep superheater outlet steam gage and thermometers under constant observation, It is also extremely important that all steam line valves between the superheater outlet and the propulsion and generator turbines be kept under observation, to insure that one will not he inadvertently closed, thus stop-ping steam now through the superheater and making thermometers and alarm at superheater outlet inoperative. With no steam flow these instruments will not indicate the true steam temperature at the super-heater outlet.

(2) To meet the changes in load called for by maneuvering conditions, it will be necessary to cut out or cut in burners under both the saturated and superheater sides. On a reduction in load, first cut out one burner on the superheater side, then one on the saturated side and. if necessary, continue this procedure until all burners have been extinguished. On an increase in load, first cut in two burners on the saturated side, then one on She superheater side and then, alternately, one on the saturated and super-heater sides until the load requirement has been met, as indicated by the superheater

(*h*) With sufficient steam flow through the super-heater, and with a burner lighted off an the super-heater side, as described, the steam temperature as indicated by the thermometer at the superheater out-let, should slowly rise and reach 525 degrees F. within a period of 5 minutes after the burner was lighted off. If this condition prevails, the firing rate on the super-heater side may then be slowly increased until the steam temperature indicated by the superheater outlet thermometer(s) equals that being carried on the main steam line to which the boiler is to be cut in (approximately 10-15 minutes after lighting off first burner).

(*i*) With main steam line valves in engine room open and the pressure on the boiler to be cut in at least 10 p.s.i. higher than line pressure prior to cutting in, to assure continuation of steam flow through the super-heater. and the steam temperature at the superheater outlet of the incoming boiler equal to that of the main steam line in operation, slowly open the main steam stop valve (*B*) to the wide open position. If valves in steam line to turbo-generator have been operated as noted above, open valves (*O*), (*P*), and (*T*) slowly to the wide open position.

outlet steam gage and thermometer.

(3) After steady steaming conditions have again been established, check all boilers for uniformity as to the number of burners in service under the saturated and superheater sides of each boiler unit. Final adjustment to maintain desired steam temperature at superheater outlets can then he made by proper manipulation of the fuel-oil pressure regulating valves in the fuel-oil header line leading to the saturated and superheater side of each unit.

(e) To Secure Boiler.

(1) To secure a boiler, start on the superheater side and, alternately, secure one burner each on the superheater and saturated sides and continue this procedure until one burner on the superheater side and two on the saturated side remain in service. These three remaining burners should then be secured as quickly as possible; the one on the superheater side to be secured first.

(2) The main steam stop and turbo-generator steam line stop valves should then be closed, to stop the flow of saturated steam through that superheater, and the boiler allowed to vent any steam which may be generated after burners are secured, through the auxiliary steam connection on the boiler drum. After the generation of steam has ceased, the auxiliary steam stop valve should be closed.

(3) After the boiler pressure has dropped to below that prevailing on the high-pressure drain system, the individual superheater header drains should be opened to the bilge. (Close valve (E) and open valves (F), fig. 30A,)

(f) Superheater Casualty.-In the case of a superheater casualty which requires securing the boiler, proceed as outlined in Paragraph 5 (e) (1). In addition, as soon as all burners have been secured, *see that the air registers of all burners are in the fully closed position and that the forced draft fans are immediately secured*. This will allow the superheater tubes to cool gradually and thus prevent the possibility of an air quenching action which would cause embrittlement of the

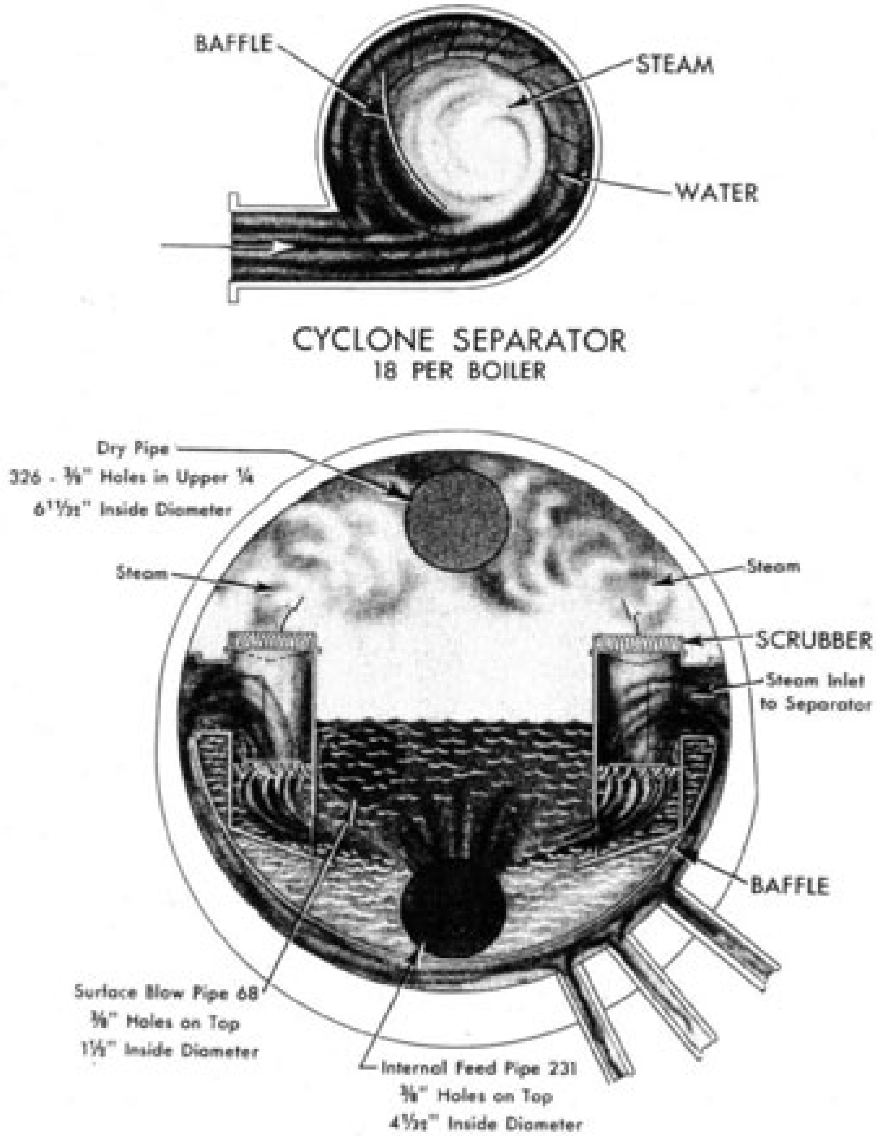
blow pipe is located just below the normal water level of the drum. This pipe also extends the length of the drum, with a single row of three-eighths inch holes drilled in its top. When the surface blow valve is open this pipe serves to carry off scum and foam from the surface of the water in the drum. A continuous baffle, raised about 3 inches from the drum itself but below the internal feed pipe, is fitted as shown from about the middle of the drum on one side to the middle of the drum on the other side. This baffle extends in length from just forward of the generating tubes to just aft of them but does not reach as far as the downcomers. The forward and after ends of the space left between this baffle and the drum are closed by a sealing bar attached to the drum. The baffle is attached at both sides to a flat bar which is hung from the drum as shown and extends the full length of the baffle. In each of these flat bars are cut nine ports. Over each of these ports is placed a cyclone separator. This arrangement makes the space between the steam drum and the baffle an entirely enclosed space, with the exception of the ports leading to the cyclone separators. The flow of steam and water through the drum is as follows: water enters the drum through the internal feed pipe and flows through the downcomers into the water drum. In the water drum the circulation is upward through the generating tubes where heat is transmitted to the water, and steam is formed. The generating tubes discharge this mixture of steam and water into the space behind the baffle. Since this space is entirely enclosed, the only passage available for the steam and water is through the ports admitting to the cyclone separators. The nine separators on each side of the drum have sufficient capacity to pass all the steam and water which may flow, up to 120 percent of rated load. As the mixture passes through the cyclone the steam is separated from the water and passes through the top of the separator. The water discharges from the bottom of the separator. As the steam leaves the cyclone separator it passes through a scrubber where it is dried and then finally leads to the top of the drum where it can be picked up by the dry pipe.

tube metal and ultimate tube failure.

6. INTERNAL FITTINGS

(a) General Description.- A number of internal fittings are installed in the steam drum which furnish various services to the boiler. The dry pipe runs the entire length of the steam drum, and is suspended in the top of the drum. The top of this pipe is perforated throughout its entire length with a number of three-eighths inch holes. Connections from the dry pipe pass through the top of the steam drum to the boiler mountings from which steam passes to the auxiliary steam line and to the superheater. The holes are located in the top of this dry pipe because the steam in the top of the drum is the dryest steam and it is this steam which must be taken off. The internal feed pipe extends along the entire length of the steam drum, at the bottom (fig. 31). Through it feed water is admitted from the economizer to the drum in a manner which distributes it evenly throughout its length, through three-eighths inch holes to allow for the discharge of the water. The surface

(b) Cyclone Separators.-The details of the cyclone separator, its strainer and scrubber are shown on the drawing of the internal fittings (fig. 31). The steam enters the separator through its inlet connection which is tangent to the separator body. Entering on this tangent, a rotating motion



INTERNAL BOILER FITTINGS
FIG. 31

is imparted to the mixture of steam and water. Due to the greater weight of the water it is thrown to the outer side of the cyclone separator body and the steam, being lighter, remains toward the center. An internal baffle is so located that the water passes outside of the baffle and the steam is deflected by the baffle to the center, thus allowing the steam to rise through the center of the separator while the water, with its greater weight, gradually falls to the base of the separator. Curved vanes can be seen in the bottom of the separator. These vanes are stationary and serve the purpose of maintaining the water in its rotating motion until it is finally discharged from the bottom of the separator. In the center of the separator and attached to these vanes is a flat plate, the vanes being located only around the periphery of this plate. This serves to prevent the steam, in the center of the separator, from being carried out the bottom by the water. The vanes, being located only around the periphery of this plate, allow the water to pass from the separator only around the

outer edge of the body. The two end cyclone separators on each side are fitted at their base with a flat baffle. This flat baffle directs the flow of water from the separator to the center of the steam drum where it will mix thoroughly with the rest of the water in the steam drum and not flow directly from the separator into the down-comers. The action of this cyclone separator serves to deliver dry steam to the dry pipe with a minimum of agitation of the water, thereby reducing the possibility of priming.

7. SAFETY VALVES

(a) General Discussion.-Each boiler is fitted with three safety valves on the steam drum, and one safety valve on the superheater outlet elbow. These valves are generally designated as follows:

> A valve is the first drum safety, or "drum pilot" valve.
> B valve is the second drum safety valve.
> C valve is the third drum safety valve.
> D valve is the superheater safety valve.

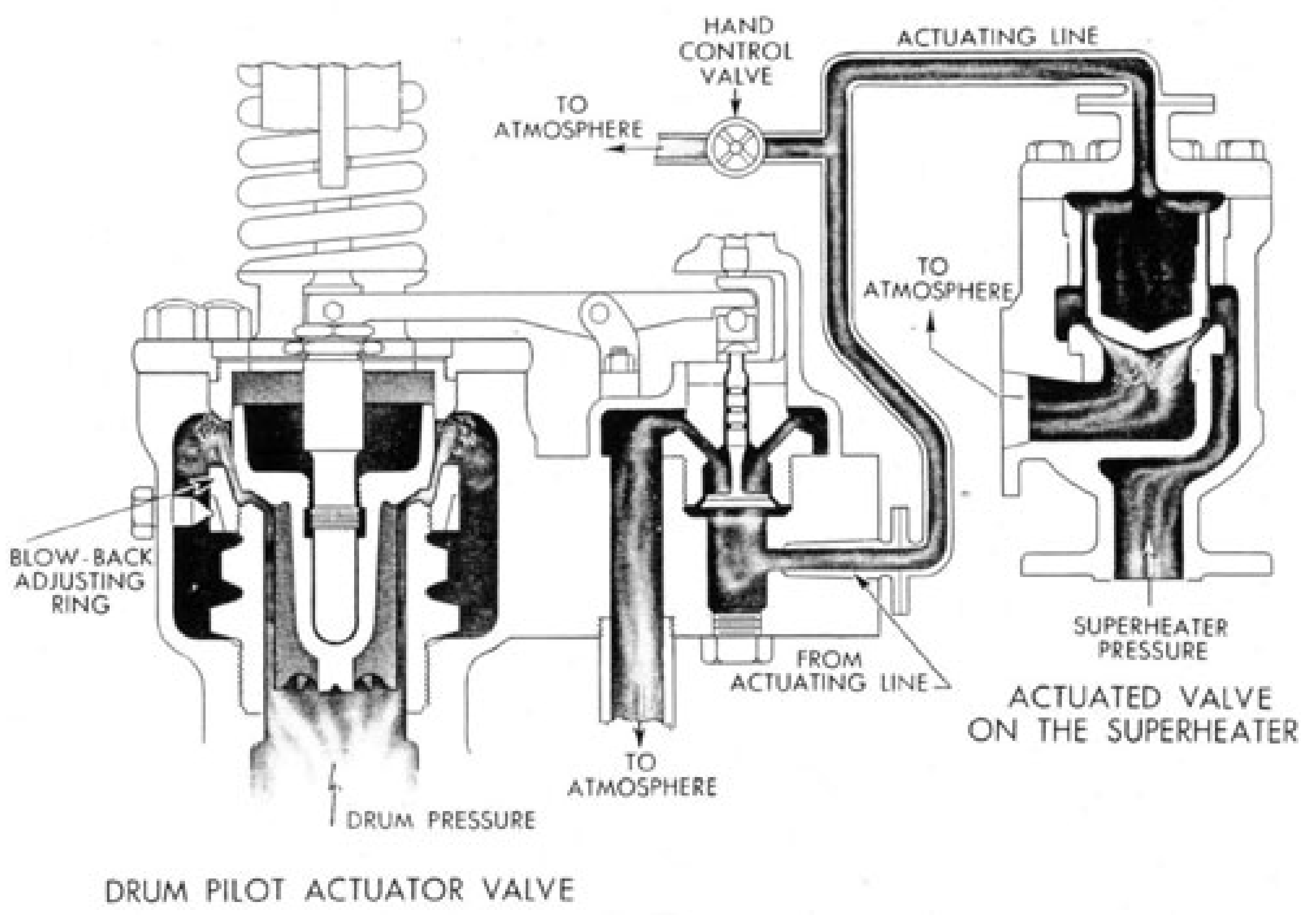
The A valve is set to lift at 634 p.s.i. and to re-seat at 615 p.s.i. Since this valve is connected mechanically to the superheater actuator valve, the superheater valve (or *D* valve) will be caused to lift at the same time. The *B* valve is set to lift at 639 p.s.i. and to reseat at 620 p.s.i. The *C* valve is set to lift at 644 p.s.i. and to reseat at 625 p.s.i. It will be noted that the reheating pressure of the first drum safety valve is the sane as the maximum boiler operating pressure. Figure 32 shows sectional views of the drum pilot valve *A*, the superheater actuator and the superheater safety valve. No sketch is shown of the *B* or *C* valves since the operation of the *A* valve is exactly the same in spite of the minor differences in construction.

(b) Operation.-As indicated in figure 32 the steam proportionate to the pressure of steam supplied. In the case of a safety valve this cannot be al-lowed, as the pressure in the boiler must be pre-vented from rising further. Therefore, the valve must be caused to open fully when lifting pressure is reached. To accomplish this a flat collar, called the feathering ring, is machined in the valve disc above the valve seat. As soon as the valve starts to lift pressure passing through the seat comes into contact with this feathering ring. This adds an additional area against which the steam drum pressure can work and increases the total force on the disk so far above that of the spring that the valve is thrown wide open. This is what causes a safety valve to "pop" instead of creep open.

(c) Blowback.-The blowback of the valve is the pressure drop in the steam drum required before the valve will reseat. Because of the additional area presented by the feathering ring the valve will not. resent at the lifting pressure. but only at a pressure where the spring force and the force of steam applied to the new total area of the valve are equal. With no method of adjusting the balance of these forces, the resenting pressure would be far below the normal boiler operating pressure due to the additional area of the feathering ring. In order to balance these forces at the proper pressure a blowback ring (fig. 32) is provided, and an orifice is drilled through the valve disc from the chamber up to the space above the valve disc. Adjusting the location of the blowback ring by screwing it up or down will vary the area available for steam to escape past the valve disc, and will therefore vary the pressure built up in the annular space below the feathering ring. This will cause an increase or a decrease in the pressure working against the feathering ring and a corresponding increase or decrease in the pressure bled through the orifice. Proper adjustment of the blowback ring can be made so that the balance of forces on these two areas will allow the valve to resent with the blowback required, 19 p.s.i. in this case.

drum pressure is in contact, with the bottom of the valve disc of the *A* valve at all times. This steam pressure exerts a force on the disc. tending to force it. open, which increases as the pressure in the drum increases. The heavy spring, located above the valve bonnet, exerts a force downward against the valve stem which continuously tends to keep the valve closed against this steam pressure. When the total force exerted on the bottom of the valve disc becomes greater than the force of the spring pressing down, the valve disc will start to lift from its seat. In ordinary relief valves the amount of this lift is directly

(d) Drum safety Valves.-The action of the drum safety valve is the same as that of the drum pilot valve. They differ in construction by not having the skirt shown below the valve disc on the drum pilot valve and by having, in proportion to their size, a smaller degree of lift. Adjustment of the blowback ring is accomplished in the same manner as in the description of the drum pilot valve.



DRUM PILOT ACTUATOR VALVE
FIG 32

(e) Superheater Actuator and Superheater Safety Valves.-Built into the same body casting as the drum pilot valve is the superheater actuator valve. Opening of this valve is what finally causes the superheater safety valve to lift. A rocker arm working from the valve stem of the drum pilot valve rests against a ball which is in contact with the valve stein of the actuator valve. When the drum pilot valve lifts this rocker arm causes the actuator valve to open. The outlet side of this actuator valve is connected to the atmosphere through an open drain. The inlet side of the actuator valve is connected to the superheater safety valve as shown in figure 32. The superheater safety valve consists of a piston type disc, with no stem, which is held in line by the cylinder in which it works. The bottom of this valve disc is connected with the atmosphere through the escape piping. As shown in figure 32, steam enters from the superheater outlet elbow and gathers around the valve disc above the seat. A feathering ring similar to that shown in the *A* valve is machined into this disc also. It is apparent from the drawing that the only pressure working above the valve disc is the superheater pressure against this feathering ring. Small ports are provided through which steam from the super-heater can bleed into the space above the super-heater safety valve disc. This space is connected by a pipe to the inlet side of the actuator valve. With the actuator valve closed this makes a closed system, and steam bleeding through the above-mentioned ports will cause pressure to build up in this system until it is equal to that in the super-heater outlet elbow. This pressure on top of the valve disc holds the valve closed. Then, if the superheater actuator valve is opened by causing the A valve to lift, this will open the enclosed space to the atmosphere and allow the pressure to bleed off. When this pressure is bled off the only remaining force on the superheater valve disc is that working against the feathering ring on the superheater valve discs. This is sufficient, with no pressure above the superheater disc, to force the the steam drum, the superheater safety valve must lift immediately thereafter. And when the drum pilot valve resents the superheater safety valve must also reseat.

(f) Operation.-It is to be noted that the superheater safety valve does not lift due to excessive pressure in the superheater but only when excessive pressure is reached in the steam drum. This is necessary to protect the superheater. Should a drum safety valve lift without the superheater safety valve also lifting, the pressure in the steam drum might blow down without blowing down the pressure in the superheater. This would destroy the drop in pressure through the superheater and, therefore, the steam flow through the superheater would cease. In extreme cases steam might even flow backward from the superheater to the drum. In any case, it would cause overheating of the superheater since there would be no flow of steam through the superheater to carry away the heat transmitted into it. The blowback ring here-to-fore mentioned, is prevented from vibrating out of position by a pin inserted through the body of the valve. The tip of this pin extends between notches of the blowback ring and prevents it from turning. Care must be taken to insure that the tip does not press against one of the raised edges. When the pin enters fairly into a notch it can be screwed fully home by hand. Attached to the yokes of the three drum valves are levers. These levers are all connected by wires to a single hand-wheel. Turning this handwheel will lift successively, the three levers and open by hand the three safety valves. When the *A* valve is lifted, the superheater safety valve will also be caused to lift by the actuator valve. This should always be done if lighting off a boiler when the drum pressure reaches 500 p.s.i. Leading from the actuating line between the actuator valve and the superheater safety valve is a hand-operated valve which connects to the atmosphere. Opening this valve will bleed the pressure from the actuating line and cause the superheater valve to lift without lifting the *A* valve. This hand valve should not be used for testing the

superheater valve open and allow steam pressure to be relieved from the superheater. When the actuator valve closes due to resenting of the drum pilot valve, pressure bleeds rapidly into the space above the superheater valve disc, building up a pressure on top of the disc and thereby closing the valve. It is obvious that when the drum pilot valve lifts due to excessive pressure in superheater valve, but should be operated only when it is necessary to increase the steam flow through the superheater, while still maintaining operating pressure in the steam drum. This condition might occur when it is necessary to raise superheat on the boiler before placing it on the line.

8. SUPERHEATER PROTECTION DEVICES

(*a*) Superheater protection devices are instruments which measure the drop in pressure through the superheater. The pressure drop through the superheater is an indication of the amount of steam flowing through it. For any superheater, the pressure drop varies directly as the square of the steam flow. The instruments are installed to guide the fireman in the operation of the superheater side oil burners. When sufficient flow has been established through the superheater as indicated by the superheater protection device (2.0 inches of water) the superheater side burners may be cut in. Likewise, when the steam flow through the superheater drops below 2.0 inches of water, the superheater side burners must be secured to prevent overheating of the superheater tubes due to insufficient cooling by the steam. There are two different types of superheater protection devices used in naval vessels, namely, Yarnall-Waring and Bailey Meter. DD445 class destroyers are equipped with either the Bailey Meter or the Yarnall-Waring devices. DD692 class destroyers have Yarnall-Waring instruments.

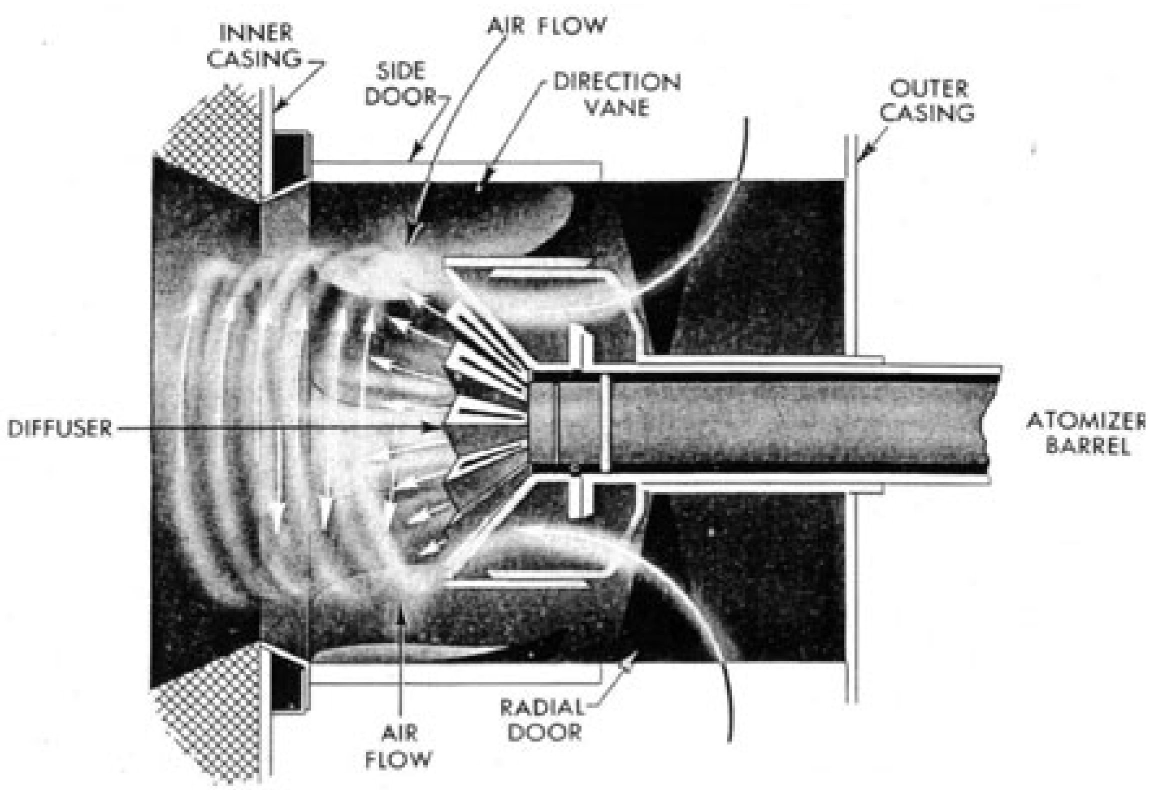
(b) Yarnall-Waring.- This device responds to the difference in pressure on two columns of water. A constant water level is maintained in the two reservoirs or head chambers. The upper head chamber is physically attached to the lower head chamber, but two inches above the lower head chamber to provide a slight pressure differential of the well in response to variation in pressure causes greatly amplified rotary response of the armature and attached pointer hand. The pointer hand swings over a brightly illuminated vertical dial divided into red and green zones to represent safe and unsafe conditions of operation. All superheater protection devices on the DD445 and DD692 classes should have the division line between the red and green zones set opposite the 2-inch mark on the graduated scale.

(c) Bailey Meter.-Bailey Low Flow super-heater protection device also responds to a difference in pressure on two columns of water. A constant water level is maintained in radiator reservoirs. Pressure piping, one from each reservoir, connects the reservoirs to the superheater inlet and outlet steam piping. Root valves are located in these lines where they tap onto the steam line to shut off the instrument in cases of emergency. The valves should normally be sealed in the open position and closed only by authorized personnel. This device is an electronic telemetering system consisting of three basic elements: (1) transmitter which is actuated by differential pressure, (2) indicating receiver, and (3) a vacuum tube amplifier and motor control unit.

(*d*) A transmitter is connected to the radiator reservoirs so that a differential pressure is applied across a bellows. A nonmagnetic rod running between the free end of the bellows and the iron core of the movable core transformer, transfers the motion of the bellows to the core. The rate of flow

across the instrument. A high pressure connection from the superheater inlet steam piping leads to the upper head chamber, while a low pressure connection from the superheater outlet steam piping leads to the lower head chamber. Root valves are installed in these connections to permit isolation of the device in case of failure. These valves should normally be locked or sealed in the open position. At the indicating unit the heads of water are terminated on opposite sides of a diaphragm. The diaphragm in turn is connected by pin point linkage to a deflection plate, which deflects in sensitive response to the differential pressure acting on the diaphragm. A permanent magnet is rigidly mounted to the extended end of the deflection plate and its poles straddle a thin tubular well. Inside the tubular well a spirally formed strip armature is axially mounted on jeweled bearings and a counter-balanced pointer is attached to the end of the mounting shaft. Relatively slight amount of movement of the magnet along the axis through the superheater i.e., the pressure differential, as represented by the position of the iron core is transmitted electrically as a ratio of the output voltages from the two secondary windings of the transformer. Care must be exercised when cutting the transmitter in or out of service in order to prevent rupture of the bellows by applying full pressure to only one side of the bellows. An equalizing valve is instalIed on the side to the transmitter so that the pressure can be equalized while cutting the transmitter in or out of service.

(e) The indicating receiver consists of a calibrated slide-wire potentiometer unit which is positioned by a small high torque reversing induction motor to balance the voltages as set up by the transmitter. This reversing motor positions the indicating pointer through linkage, and also operates a contact which should be set to close at 2 inches of water on all DD445 class vessels (approximately 5,000 pounds of steam per hour). When the steam



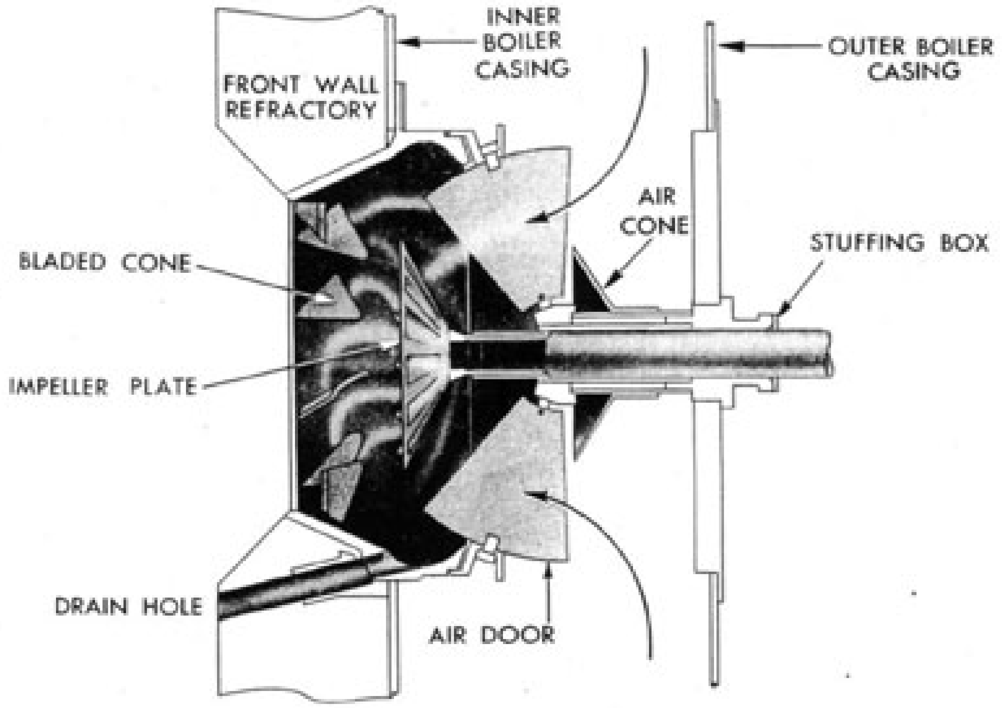
TODD AIR REGISTER
FIG. 33

flow through the superheater is less than 5,000 pounds per hour, the contact closes an electrical circuit which illuminates the instruction plate which reads. "Secure Superheater Burners." The amplifier and motor-control unit detect any electrical unbalance of the bridge formed by the secondary windings of the movable core transformer at the transmitter and the slide-wire of the receiver. When unbalance is caused by movement of the iron core. due to a change in the rate of steam flow to the superheater, this unit operates the reversing motor to move the slide-wire and rebalance the circuit.

9. FUEL OIL BURNERS

(a) General Discussion.-Four fuel-oil burners are installed on the saturated side and three on the superheater side. Either of two different types may be installed; the Todd fuel-oil burner or the B & W Carolina fuel-oil burner. A fuel-oil burner consists of, first, an atomizer, the purpose of which is to break the fuel oil up into a fine spray; and, secondly, an air register, the purpose of which is to admit air to the boiler in the proper amount and direction to accomplish complete intermixture with the oil spray. Figures 33 and 34 show the two different registers. Figure 35 is the fuel-oil atomizer. The only difference between the atomizer in use with the Carolina register and that in use with the Todd register is the presence of the bearing collar on the Todd atomizers.

(b) Todd Register.-The Todd register is attached as a single unit between the inner and outer casings of the boiler. so that the air pressure leading between the casings of the boiler surrounds the register. Air is admitted to the furnace and passes through the side and radial doors shown in figure 33. These doors are interconnected so that by means of canes and operating levers they are all opened and closed simultaneously. Operation of the]ever outside the boiler causes these doors to open or close to the degree at which the lever is thrown. The diffuser indicated in figure 33 is attached to the outer barrel and consists of a fan-shaped cone with slots cut in it. The atomizer passes through the outer barrel and discharges its



THE "CAROLINA" AIR REGISTER
FIG. 34

spray of oil from the center of this diffuser. Opening the radial doors admits air to the rear of the diffusers which causes the air to flow parallel to and around the cone of oil spray. The slots in the diffuser allow a small amount of air to pass through and come directly into contact with the oil, but do not allow sufficient air to pass through to destroy the form of the oil cone. Air entering the side doors is forced first to pass over the direction vanes shown. These vanes are curved so as to force the entering air to flow in a rotating direction and thereby wrap itself around the cone of oil spray. This action insures a complete mixture of the air with the oil in the cone, yet does not allow the rush of air to destroy the form of the oil cone. The atomizer is inserted in the outer barrel and the tip is located at the base of the diffuser. The outer barrel is capable of being moved back and forth to adjust the position of the atomizer and diffuser relative to the furnace cone. The outer barrel is graduated to show inches of withdrawal and adjustment of the location of this barrel is necessary to obtain clean and efficient combustion at different firing rates.

(c) Carolina Register.-The Carolina register serves the same purpose as the Todd register and by a different arrangement causes the air and oil to be thoroughly mixed, by rotating the air around the oil cone. Only a single set of doors is provided in this register, all opening simultaneously by the operation of a crank. Before these doors is located an air cone which causes the air to flow to the outer area of the door before entering the register. An impeller plate. which corresponds to the diffuser of the Todd register, is located in approximately the same position as the diffuser. Slots are cut into this impeller plate and the metal from the slots is bent away. The air entering through the doors strikes this impeller plate. Part of it is forced to flow parallel to the oil cone and part is allowed to pass through the slots and is directed by the metal bent away, in a manner which causes it to rotate around the cone of oil. The bladed cone causes the air which enters outside of the impeller to flow in a rotating motion and also serves to maintain the rotation of the air passing through the slots. This rotation accomplishes the same purpose discussed with the Todd register;

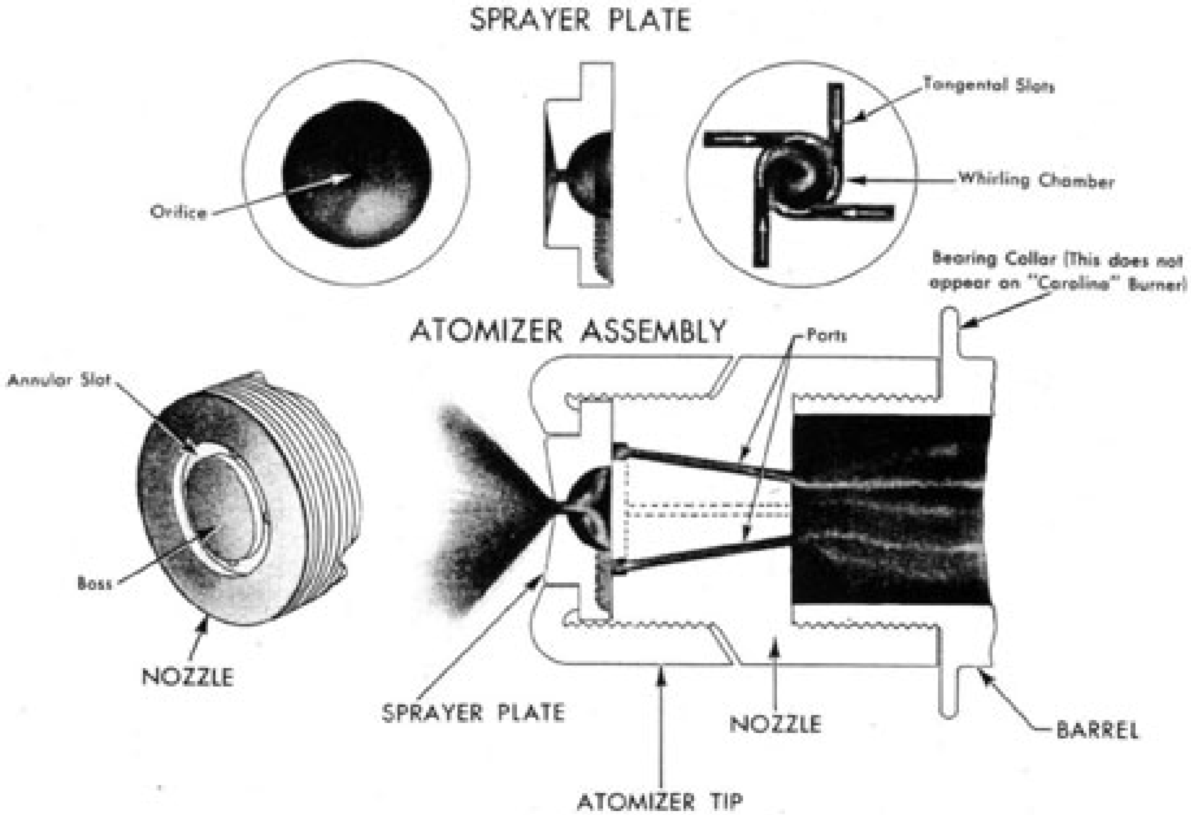
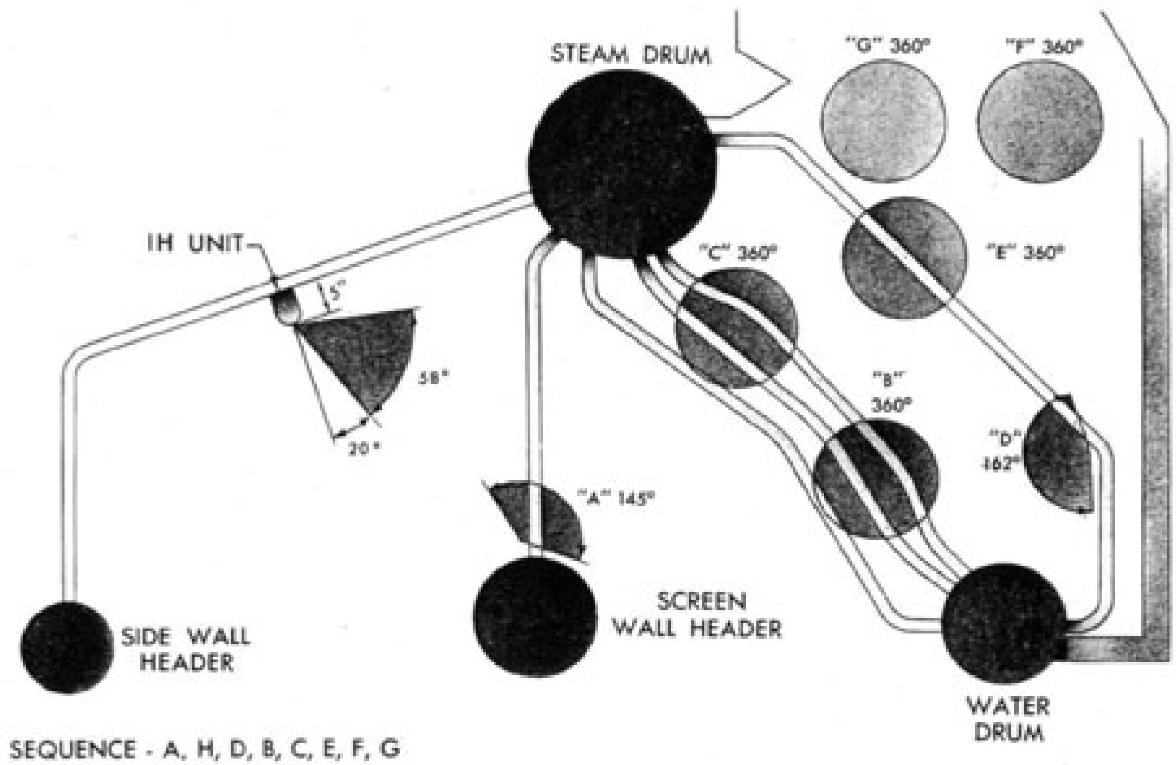


FIG. 35

i.e., the complex mixture of air with the oil discharged from the atomizer. The atomizer is inserted into an outer barrel which is very similar to that of the Todd burner and which can also be moved in and out relative to the furnace of the boiler to accomplish most efficient operation of the burner at various firing rates.

(d) Fuel Oil Atomizer.-The four major parts of the atomizer are the barrel, nozzle, sprayer plate and tip. Figure 35 is a sketch of the Todd atomizer. The Carolina atomizer does not have the bearing collar shown on the barrel. However, in all other details these atomizers are the same and their operation is the same. Screwed onto the barrel, as shown, is the nozzle. Ports are drilled through this piece which lead into an annular space in the face of the nozzle. The rear face of the sprayer plate is pressed against the face of the nozzle by the atomizer tip. The only purpose for this tip is to chamber, is an orifice through which the oil discharges from the atomizer. Oil passes through the barrel, enters the ports of the nozzle, and discharges into the annular space into the face of the nozzle. The tangential slots in the sprayer plate reach across the annular space and receive oil from this space. Flowing through the slots, oil reaches the whirling chamber and, since it enters that chamber on a tangent, it is caused to rotate rapidly. This rapid rotation causes the oil leaving the orifice to be broken up into a fine spray. This fine spray is in the form of a hollow cone. It is this cone of oil with which the air admitted by the register mixes to obtain proper combustion in the furnace. The entire assembly is held against the oil connection outside the boiler by a gooseneck and locking screw. A swing check valve is provided to close off the outer barrel when there is no atomizer inserted. The Todd register has this check valve arranged to swing inward into a housing while the Carolina register has

hold the sprayer plate in position. The sprayer plate is constructed as shown in figure 35. The slots in the rear face of the sprayer plate enter the whirling chamber at a tangent to the chamber and, leading from the center of the whirling its check valve arranged to swing outward. Sprayer plates are furnished in various sizes for various rates of combustion; the larger the hole in the face of the sprayer plate the



SOOT BLOWER LOCATIONS AND ARCS
FIG. 36

greater the rate of oil discharge. The angle of the cone of oil spray and the degree of atomization depend upon the relation between the cross-sectional area of the tangential slots and the area of the discharge orifice. On the face of each sprayer plate is stamped two pairs of numbers. The first pair indicates the size of drill used to make the discharge orifice; therefore the larger the number the smaller the hole, and the smaller the capacity of the sprayer plate. The second pair of numbers indicates the ratio between the total cross-sectional area of the dots and the cross-sectional area of the discharge orifice. The first pair of numbers is the more important of the two

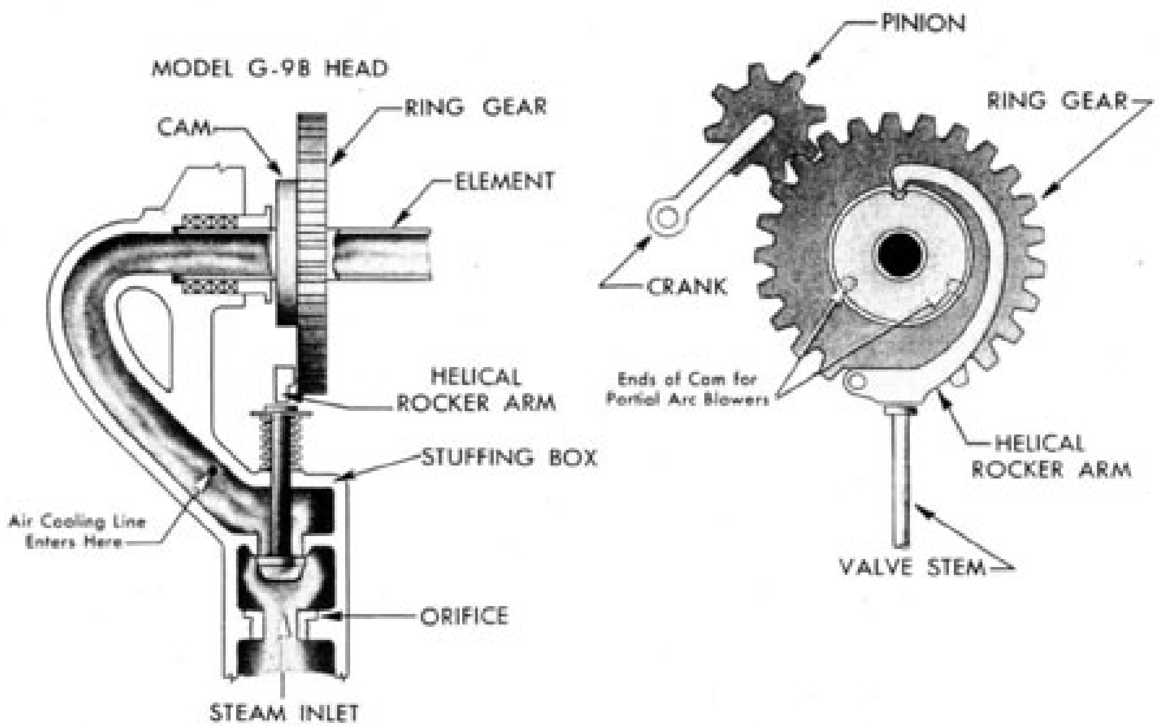
10. SOOT BLOWERS

(a) General Discussion.-Eight soot blowers are installed in each boiler, the purpose of which is to admit jets of steam to the tube nests at high velocity in order to remove soot from the tubes and allow the flow of gases to carry it up the stack and out of the boiler. Seven of these soot blowers are of the Diamond G9B type, consisting of a tube extending from one end of the boiler to the other through the tube nest. Five of these G9B soot blowers are arranged so that they will blow steam through the entire 360 degrees of rotation. Two will admit steam only through a part of their arc of rotation. Figure 36

pairs since for each air register and each drill size it different relation between the cross-sectional areas must be maintained to obtain the required spray angle. Therefore, the only definite indication of capacity is in the size of the first pair of numbers. The Todd sprayer plates are marked by a capital "T" between the second and third digits.

shows the location of these blowers and the arcs through which they blow steam. The eighth soot blower is of the Diamond "IH" type which consists merely of a spray nozzle extending into the superheated furnace and blowing steam from a single nozzle across the super-heated tube nest.

(b) The G9B Blower.-The G9B soot blower



SOOT BLOWER HEADS
FIG. 37

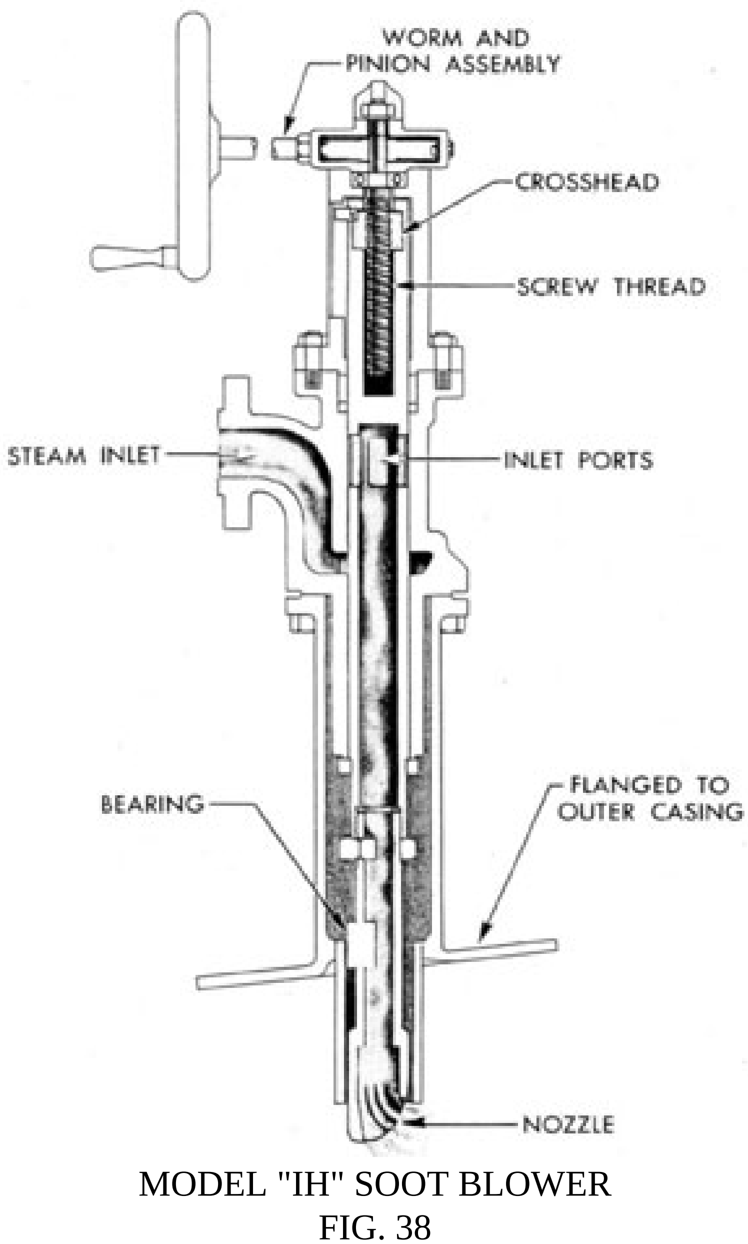
consists of a single tube extending through the tube nest, which has a series of nozzles drilled into it. These nozzles are so arranged that steam discharging from any one will not impinge directly on an adjacent tube. Steam is admitted to this tube through the arrangement of a cam and helical rocker arm (fig. 37) . The earn is rotated by operating the gears shown in the same figure. Steam enters directly from the superheater outlet and when the gears are rotated, it passes through the valve to enter the soot blower tube or element. To allow for steam blowing through only a partial arc the cam is cut away and appears only for that

the steam inlet connect ion and steam is allowed to blow through the tube, into and across the super-heater tube nest. The angle of discharge of the nozzle is 58 degrees. Figure 38 provides a good illustration of this soot blower.

(d) Operation.-As will be noted in figure 36, each soot blower element is indicated by a letter. These letters are used to facilitate explanation of the order in which they should be operated. A specific order of operation should be used in order to obtain the greatest efficiency of cleaning. The sequence of this operation should be as follows: *A, H, D, B. C, E, F,*

portion of arc through which it is desired to blow steam.

(c) IH Soot Blower.-The IH unit consists of a hollow tube carrying a fan shaped nozzle at its end. When in the secured position, this tube rests in a shrouding between the inner and outer casings of the boiler. When operated, turning the hand-wheel will cause this tube to be extended as far as five inches into the superheater furnace. As the tube reaches the end of its travel ports line up with and *G*. In some instances it may not be possible to operate these separately in this sequence since the time allowed for blowing tubes may not be sufficient. In this case a fairly efficient cleaning may be accomplished by operating the soot blowers in pairs in this order: *A* and *H*, *D* and *B*, *C* and *E*, *F* and *G*. A drain valve is provided in each soot blower steam system to drain the piping before admitting steam to the elements. This must be opened before operating the soot blowers. To provide continuous drainage during operation



MODEL "IH" SOOT BLOWER
FIG. 38

a one-eighth-inch hole is drilled through the valve disk. To provide for cooling of the soot blower elements when not in operation a pipe line is led from between the inner and outer casings of the boiler and enters the soot blower gooseneck beyond the valve. This allows for a continuous flow of air through the soot blower element to prevent it from overheating. A check valve is provided in this line so that steam will not flow back into the casings when the soot blower is operating. When operating a soot blower it should be maintained continuously in rotation. If the soot blower is not continuously rotated, the reaction from the flow of steam through the nozzles will cause the soot blower element to become bowed between its bearings, thereby preventing it from rotating.

11. BOILER BLOW PIPING

A boiler blow line is provided for the purpose of blowing down the boiler to reduce the salinity of the boiler, discharging overboard. A valve is attached to the mud drum of the boiler and leads (fig. 39) through a guarding valve, and finally overboard through another guarding valve and a sea valve. The surface blow line also leads into this line before the first guarding valve. The screen wall header and the side wall header also have valves fitted to them which discharge into this boiler blow line before the first guarding valve. However, no handwheel is provided on these valves from the two headers, since they should serve in most cases as drain valves only. The valve stem is fitted with a cap which must be removed and the valve opened by wrench or a portable handwheel. A salinity valve is led from the same fitting on the steam drum as the bottom blow valve, the purpose of which is to remove a sample of water from the boiler for test. For both boilers in one fireroom the same

smokepipes. This allows the air to be slightly preheated, as well as accomplish a certain degree of cooling of the smokepipe. They discharge into a duct which leads to the boiler between the inner and outer casing and finally through the air registers into the boiler. In each discharge duct is a set of flaps, constructed like venetian blinds, which will close automatically when only one blower is running on the boiler, and prevent the air from the operating blower from discharging back through the secured blower. Also these ducts are fitted with relief valves which are set to lift at 30 inches of air pressure, to protect the duct from damage due to excessive pressure,

(b) Operation.-The blower fads themselves are of the propeller type which are capable of discharging air to the casings even if they are operating at widely different speeds. With the old type of centrifugal fans the blowers would not parallel properly unless they were operated very closely together in speed. In this case the speeds can be apart as much as 1,000 r.p.m. and the blowers would each deliver air though the load would be unequally divided.

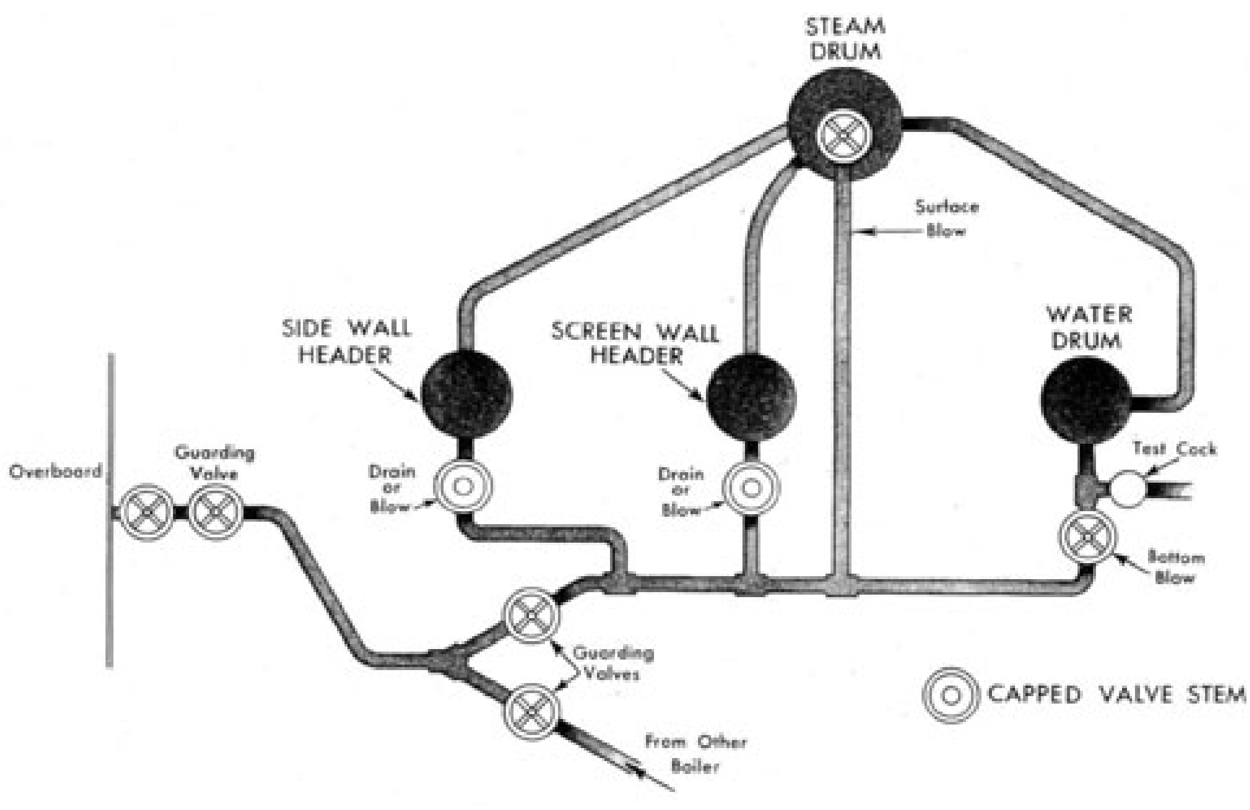
(c) Turbine.-The fans are driven by a horizontal turbine which is directly connected to the blower shaft. Control of the speed of this turbine is accomplished by two different methods, depending upon the ship in which it is installed. Some turbines are controlled by opening and closing a series of nozzle valves in the turbine. Both blowers for one boiler have their nozzle valves attached to a single handwheel on the lower level of the fireroom so that operating this handwheel will cause the valves on both blowers to open simultaneously. The nozzle valves open successively as it is desired to increase the speed of the blowers. If one blower is in operation alone it is necessary to close the root valve of the secured blower, since the nozzle valves of both blowers will open simultaneously. In other installations the four nozzle valves mentioned above do not appear, the

sea valve and outboard guarding valve are used. The first guarding valves from each boiler however are separate, their discharge leading into a **Y** which then leads to the overboard connection. It is apparent that to blow down any boiler it is necessary to open four valves-the two guarding valves, the sea valve, and finally the bottom blow valve.

12. FORCED DRAFT BLOWERS

(a) General Discussion.-The forced draft blowers installed for furnishing air to the boilers are of the propeller type. These blowers take their suction from the space between the inner and outer

nozzle block of the turbine being continuously open to the steam line. In this arrangement the root valve lending steam from the auxiliary steam line to both blowers is fitted within an extension rod to the lower level. Varying the opening of this root valve would of course vary the steam pressure to the blower chest and consequently vary the speed. To run one blower alone the root valve to the other must be closed to keep the steam pressure from



BOILER BLOW PIPING
FIG. 39

getting to the secured blower. The speed of these blowers is limited by a speed limiting governor which is a standard type of centrifugal weight governor operating on a governor throttle valve to control the steam pressure to the turbine, thereby limiting the speed of the turbine. The rated speed of these blowers for full power operation is 5,075 r.p.m., which means that the two blowers in parallel would not have to run over this speed for full load operation of the boiler. The governors are set to limit the speed of the blower at 6,350 r.p.m. which allows for sufficient excess speed for operation of the boiler at 120 percent load.

(d) Operating Instructions.-In the case of the blowers fitted with four nozzle valves no further nozzle area is required to bring the speed up to 6,350 r.p.m. In the case of the other type an overload nozzle valve is provided to allow additional nozzle area to bring the blower up to limit speed when operating with 30 inches of air pressure. This additional nozzle valve should not be opened at any time unless it is necessary to increase the blower speed beyond that obtainable with the original nozzles. Without this overload nozzle the blower will operate at about 6,100 r.p.m., which should be sufficient for 120 percent operation. This overload nozzle is particularly valuable when it is desired to operate a blower with a low steam pressure. But if opened when steam to the blower is throttled it will not only reduce the efficiency of the blower but will reduce the blower speed, due to the consequent reduction in nozzle inlet pressure. *Whenever one blower is operated alone the flaps from the other blower should be checked to see that they are closed,* otherwise air discharging backward through the idle blower will cause it to rotate backward. When this happens, the oil pump will operate backward and, no oil being discharged into the bearings, the bearings will burn out. This has been a frequent derangement in many DD445 class ships, and can be avoided by careful maintenance and checking of the flaps.

Section VII

EXPANSION SYSTEM

1. GENERAL DISCUSSION

The expansion system of the steam cycle is that part of the cycle in which steam is led from the boilers to the main turbines, and expanded in those turbines to remove the heat energy stored up in the steam and transform that energy into mechanical energy of rotation. This energy is then transmitted through the main reduction gears and line shafting to the propellers.

2. MAIN STEAM SYSTEM

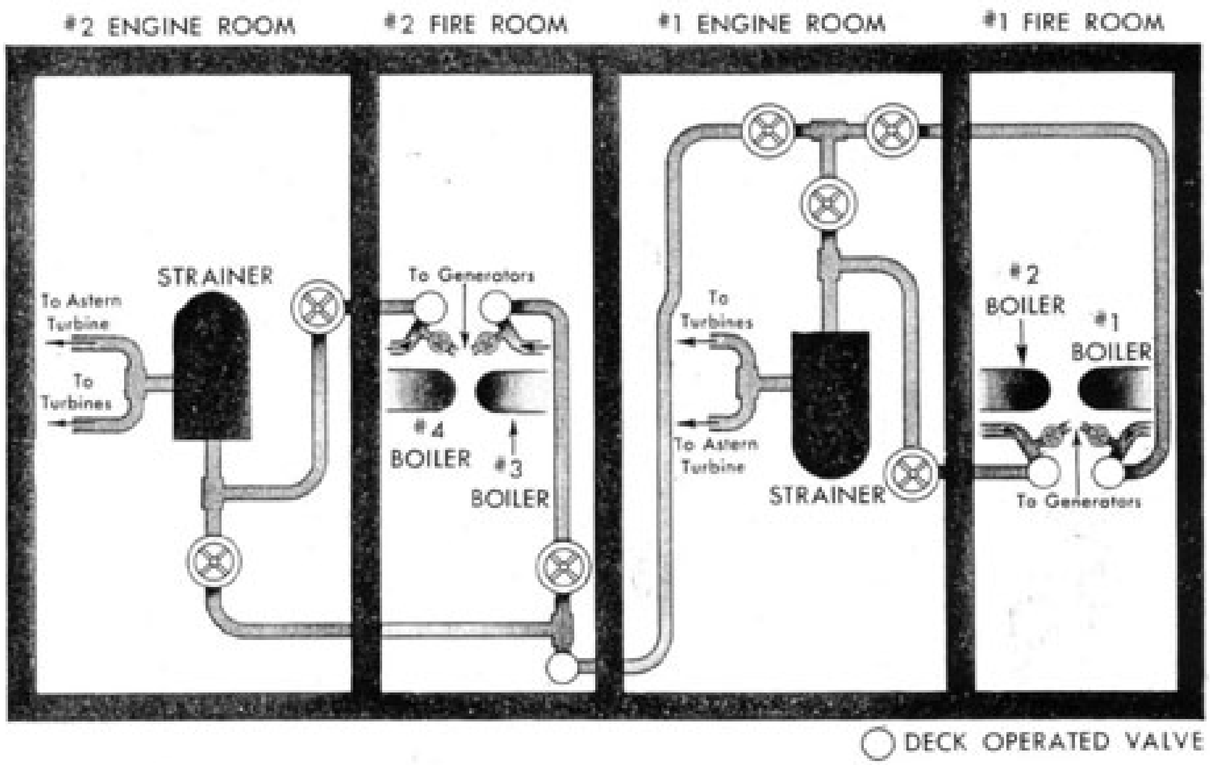
The main steam system is the piping system which leads the steam from the boilers to the main turbines. It is the simplest system on the ship. It consists of a line from each boiler, the ones from the forward boilers joining together in the forward engine room at a steam strainer to supply steam to the forward engines, and the ones from the after fireroom joining together in the after engine room to supply steam to the after engine room. The outlet from the superheater of each boiler leads to the main boiler stop valve which can be operated either from the deck or from the fireroom. From the stop valve at No. 1 boiler the line passes behind the boiler to the port side of the ship and then aft through the bulkhead into the forward engine room. In the engine room is a line cut-out valve which must be on to lead steam from No. 1 boiler to the main. The lead from No. 2 boiler stop goes directly aft on the starboard side and into the engine room where another line stop is installed, and from here joins the main before the strainer. In the main line, between the leads of No. 1 and No. 2 boilers, is another stop valve. This valve allows for operation of No. 2 boiler on the forward turbines and No. 1 boiler on the after turbines without against No. 3 boiler stop. The system is arranged to allow for either parallel or split operation of any boiler on either main engine. The normal lineup is, however, with the plant split, No. 1 and No. 2 boilers feeding steam to the forward engine room and No. 3 and No. 4 boilers feeding steam to the after engine room. In order to accomplish this division of the system it is necessary to close the cross-connection valve in the No. 2 fireroom. In addition to closing this valve, the cross connection cut-out in No. 1 engine room should also be closed to prevent steam pressure from remaining in the cross-connection line. However, in order to keep this line warmed up for immediate paralleling in case of casualty the warming up line around the valve in No. 1 engine room should be left open. This will keep the pipe warmed up and allow for immediate paralleling without taking the time to warm up the cross connection line. The general arrangement of both the DD445 and DD692 class is the same, as shown in figure 40.

A steam line has been or is being installed (Shipalt DD495) to provide a separate steam supply system to the turbo-generators. The turbo-generator steam system is arranged similar to the main steam system, and provides for split-plant or cross-connected plant operation of both generators. This line is supplied with steam by all four boilers through the soot blower connection ahead of the boiler stop. By this arrangement, flow through the superheaters is assured at all times.

3. MAIN PROPULSION TURBINES

(a) General Discussion.-The main propulsion unit for each of the plants consists of three turbines; namely, the cruising turbine, the high-pressure turbine and the low-pressure turbine. In the casing of

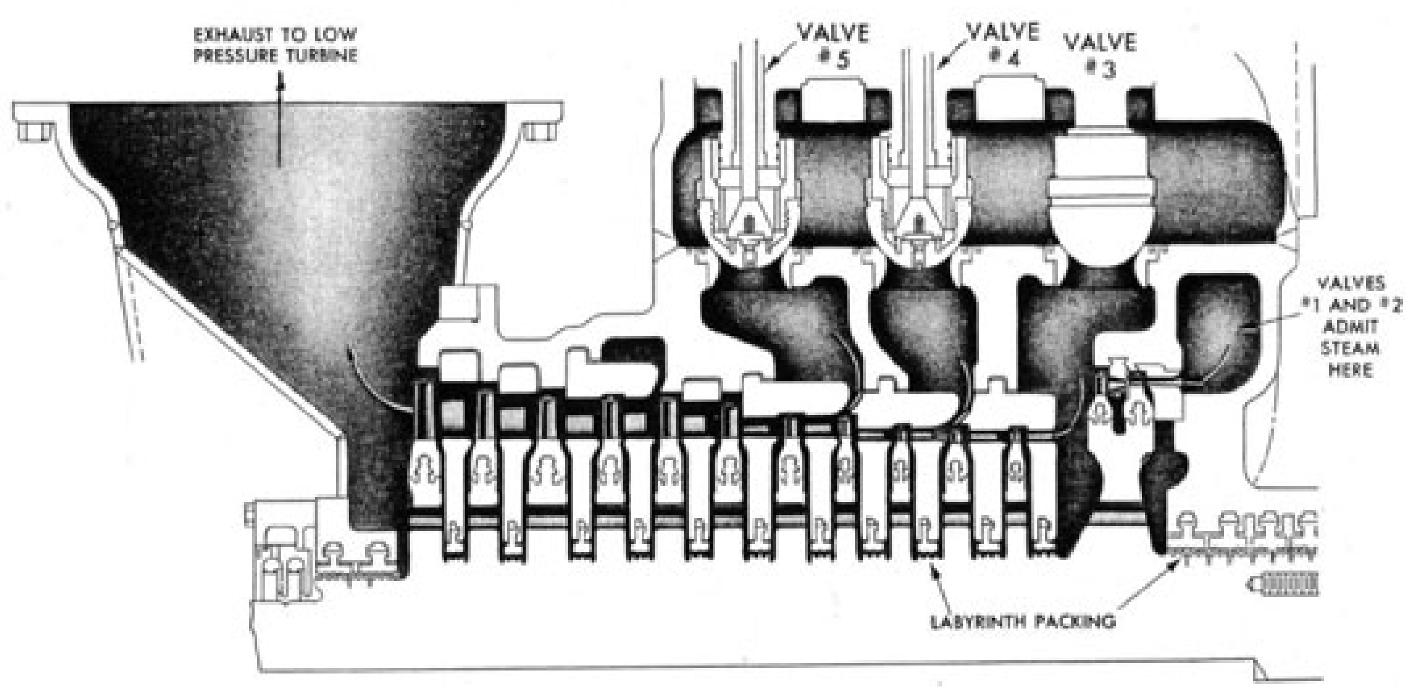
paralleling the two. The arrangement in the after fireroom as indicated in Figure 40, is very similar. The exception is that the line cut-out valve for No. 3 bailer appears in the fireroom. This is necessary because of the cross connection which leads from the main line in No. 1 engine room and joins with the discharge from No. 3 boiler in No. 2 fireroom. If the line cut-out valve were not in the fireroom, it is apparent that the system could not be cross connected without allowing the steam to back up the low-pressure turbine there are installed two astern elements. In all ships of both the DD445 and DD692 class the cruising, high pressure and astern elements are impulse turbines. The cruising and high pressure are pressure-velocity compounded, and the astern elements simple velocity compounded. Some ships of both classes have low-pressure turbines which are pressure-compounded impulse turbines and some have reaction



MAIN STEAM SYSTEM
FIG. 40

turbines. Westinghouse installations include the low-pressure reaction turbines while those by General Electric and Allis-Chalmers have the impulse low-pressure turbines. Arrangement is such that steam can flow into the cruising turbine, thence to the high pressure and finally to the low pressure, or so that the cruising turbine can be entirely bypassed and steam admitted directly to the high pressure.

(b) Turbines.-Figure 41 is a simplified diagrammatic sketch of a section of the high-pressure turbine. The space shown on the right of the drawing (labelled valves Nos. 1 and 2) is the steam chest of this turbine. The steam enters here through the two nozzle control valves, passes through the first-stage nozzle, and increases in velocity due to the drop in pressure across the nozzle. While travelling at high velocity it impinges upon the first row of blades and due solely to the velocity of the steam, it drives these blades around carrying with them the high-pressure rotor. When the steam leaves this row of blades there is still sufficient velocity remaining to warrant its use in a second row without restoring the velocity by another pressure drop. In order to accomplish this a row of stationary blades, attached to the turbine casing, is located as shown between the first and second rows of moving blades. These stationary blades reverse the direction of flow of steam so that it strikes the second row at approximately the same angle as the first row. In the second row of moving blades most of the remaining velocity is removed. From here the steam is led to a second-stage nozzle carried in a diaphragm attached to the turbine casing. The steam is expanded through this nozzle, and increases again its velocity, which is removed in a single row of moving blades on the discharge side of the nozzle. After each succeeding row of blades steam is passed through another nozzle to restore its velocity. pressure being dropped in each stage until the steam finally exhausts from the last stage of the turbine at a much lower pressure than when it entered. In the case of the high-pressure turbine, the steam passes through 12 stages in all



HIGH PRESSURE TURBINE SHOWING VALVE ARRANGEMENT
FIG. 41

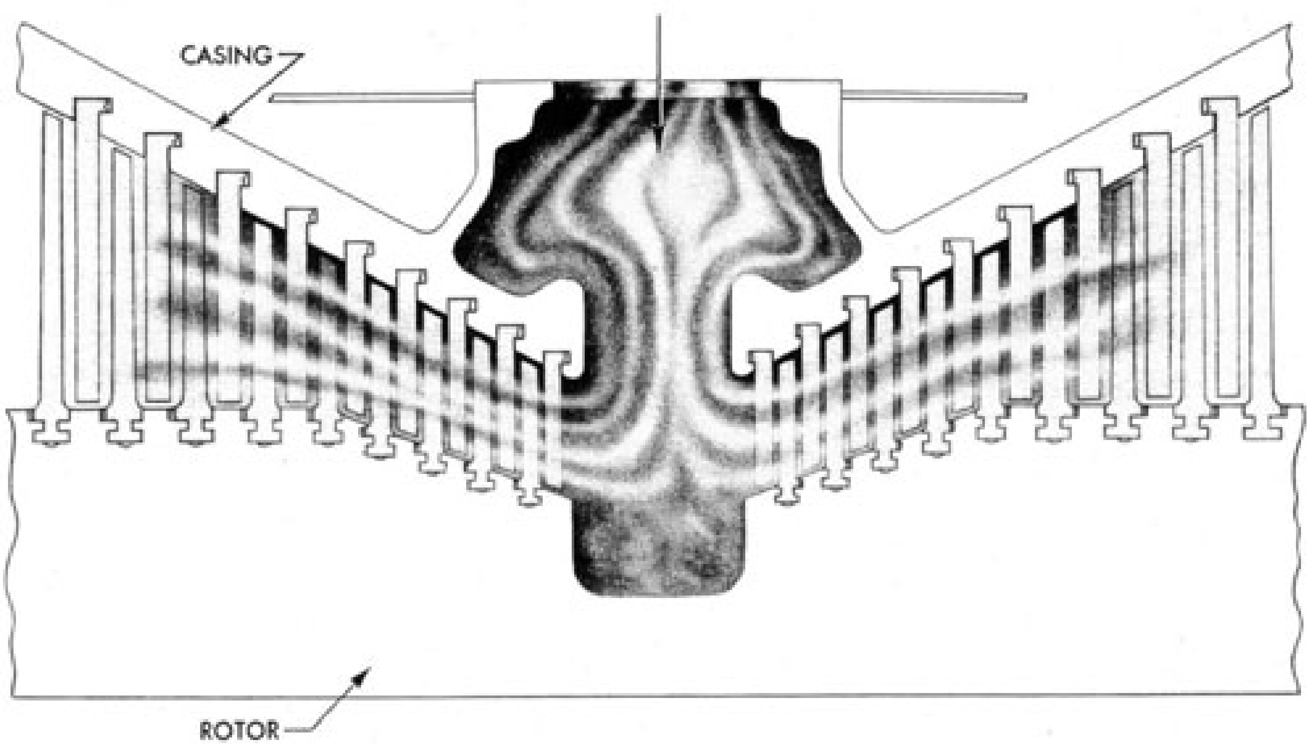
before exhausting to the low-pressure turbine. In the case of the cruising turbine, steam passes through 8 stages before exhausting to the high pressure.

(c) Nozzle Control Valves.-Three nozzle control valves admit steam to the cruising turbine via the cruising turbine chest. Operating gear leading from the main gags board rotates a cam shaft causing cams to lift these three valves successively as it is necessary to increase speed. There are five valves which admit steam to the high-pressure turbine. These valves are cam operated in the same manner as those of the cruising turbine. The first two of these valves to open admit steam to the first-stage chest (valves Nos. 1 and 2, fig. 41) of the turbine. With valves Nos. 1 and 2 fully open, the steam pressure in the first-stage chest is approximately at line pressure and the first-stage nozzles are passing steam to the first stage at the limit of their capacity. To further increase the power and speed of the turbine it is necessary to increase the amount of steam flowing through the turbine. To do this valve No. 3 is opened. This admits steam from the main line directly into the first-stage casing from where it can flow through the second-stage nozzles. This results in an increased velocity of the steam flowing through the rest of the turbine because of the increased steam volume being forced through the nozzles. The increased volume and velocity of the steam impinging upon the blading increase the turbine power and speed. With valve No. 3 wide open it is necessary to open valve No. 4 to obtain a further increase in power. This admits steam from the main line to the third-stage casing and the fourth-stage nozzles. With this valve wide open the plant should operate at its maximum allowable r.p.m. (DD445 class, 397 r.p.m.; DD692 low-pressure turbine where it is further utilized. Figure 42 is a diagrammatic representation of the reaction type low-pressure turbine. This is a double-flow turbine in which steam enters at the center of the turbine and flows in both directions through similar rows of blading, except that the blades are to the opposite hand. In the case of this reaction turbine the steam, after passing through each row of blading, is reversed by a stationary row of blades so that it enters the next row of moving blades in the same direction as before. In this turbine rotation of the blades (and rotor) is accomplished by the reaction of the blade to the flow of steam away from the blade, the drop in pressure between the stages being accomplished by the shape of the blade and by shrouding attached to the blade tips to confine the steam. There are nine rows of moving blades in each half of this reaction type of low-pressure turbine. The impulse type low-pressure turbine is also a double-flow turbine, with steam entering the center and flowing in both directions. The stages are constructed in a manner similar to those of the high pressure, in that a nozzle is provided before each row of blading and the steam is expanded through this nozzle, striking upon the blades at high velocity. There are six stages in each half of this type of low-pressure turbine. At each end of the low-pressure turbine rotor is installed an astern element. This astern element consists of a single-stage impulse turbine, velocity compounded with two rows of moving blades and one row of stationary reversing blades. At the outlet of the astern element a baffle is provided to prevent the exhaust steam from blowing directly into the low-pressure element last stage. Both the low-pressure and astern elements exhaust directly into the main condenser. See section VI, paragraph 4 (Notes on Operation) relative to super-heat control when astern bells are received.

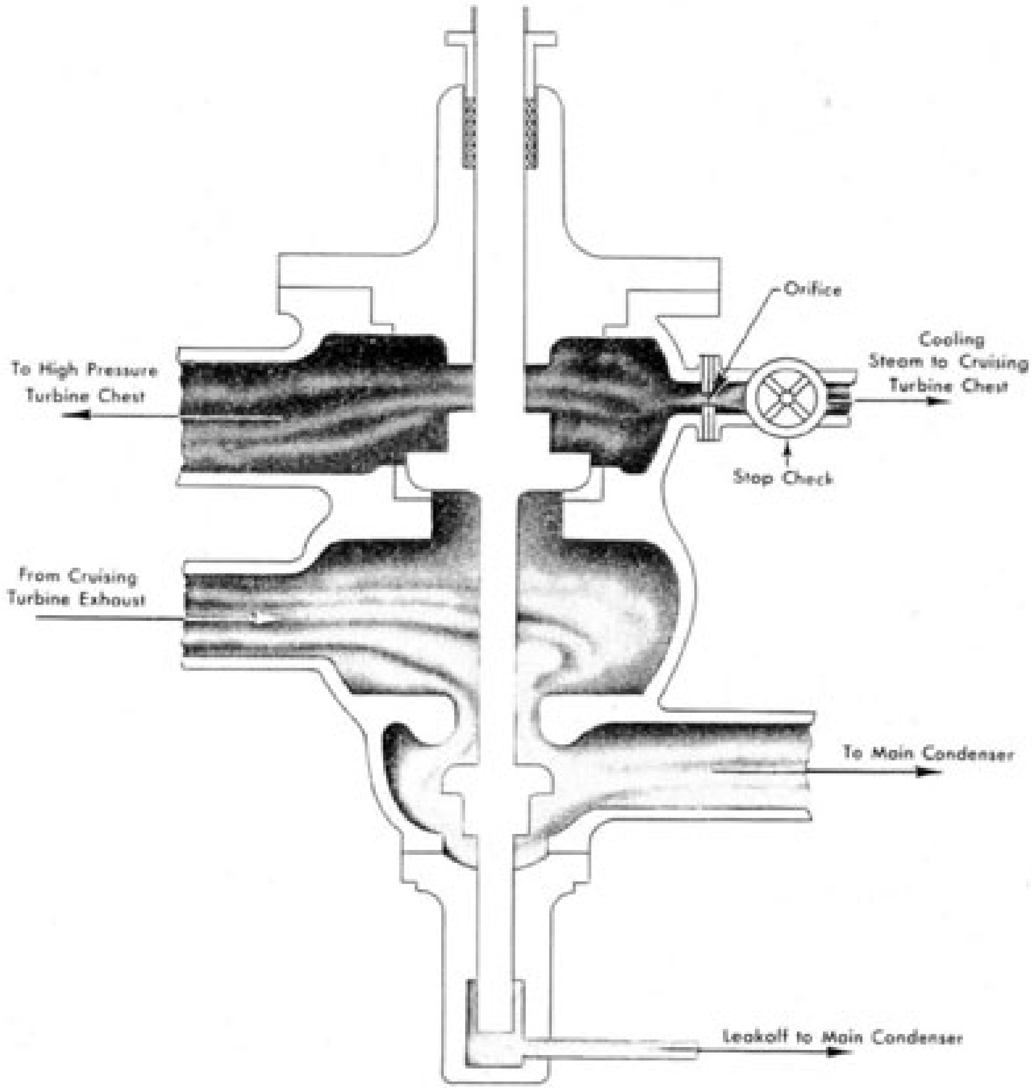
class, 350 r.p.m.). Valve No. 5 will, when opened, admit steam to the fifth-stage casing and the sixth-stage nozzles. This will permit operation of the turbine at its maximum speed and power (120 percent boiler load). Valves Nos. 3, 4, and 5 may be called "bypass" valves, but it is, perhaps, better not to think of them as such, since the term would seem to imply that the stages before each were not. in use. Such is not the case since all five valves open successively from No. 1 on and stay open. When closed, they close successively from the highest number in use.

(d) Low-Pressure Turbine.-Steam exhausting from the high-pressure turbine goes to the

(e) Cross-Over Valve.-For normal operation of the cruising turbine. the cruising turbine exhaust leads to the high-pressure turbine chest, through the high pressure turbine, and finally into the low-pressure turbine. If the cruising turbine is operating at full load, this arrangement will allow for operation of the ship at speeds up to about 20 knots. To go above this speed, steam must be admitted directly to the high-pressure turbine. For small increases in speed above this point (to 22 knots) it is permissible to admit steam to the high-pressure chest by cracking the



LOW PRESSURE TURBINE
DOUBLE FLOW REACTION
FIG. 42



CROSS-OVER VALVE
FIG. 43

high-pressure throttle without securing the cruising throttle. Since the cruising turbine exhaust is connected directly to the high-pressure chest this will cause a back pressure to build up against the cruising exhaust. This cruising exhaust pressure should never be permitted to exceed 100 p.s.i. To increase speed above 22 knots by the above means, would develop a cruising exhaust pressure of greater than 100 p.s.i. so the cruising throttle must be closed and operation continued on the high-pressure turbine alone. Some means must be provided, therefore, to disconnect the cruising turbine exhaust from the high-pressure chest when operating under high-pressure combination. Also, since the cruising turbine is connected to the high-pressure turbine through the cruising reduction gear, the cruising turbine will turn over with the high-pressure turbine even though no steam is being admitted to the cruising turbine. At the high speed of rotation which will exist in the cruising turbine under these conditions considerable heat will be built up. Some means must be provided to control this heat. To accomplish both of these purposes the crossover valve is inserted in the cruising turbine exhaust line. Figure 43 shows this to be a double valve with a common inlet to both discs. This common inlet is from the cruising turbine exhaust. The

upper valve is a 6-inch valve which, when open, allows steam to pass from the cruising turbine exhaust to the first-stage chest of the high-pressure turbine. When in this position the valve is on the cruising combination. As can be seen from figure 43, closing this 6-inch valve will cause the lower (3 1/2-inch) valve to open. The opening of this valve connects the cruising turbine exhaust directly to the main condenser, and by simultaneously closing the 6-inch valve disconnects the exhaust from the high-pressure chest. A vacuum from the main condenser then exists in the cruising turbine casing. This vacuum will accomplish a certain degree of cooling of the cruising turbine. However, this will not be sufficient to keep the cruising turbine from overheating. To carry the built-up heat away from the cruising turbine a connection is provided from above the 6-inch valve disc leading into the cruising turbine chest. With pressure on the high-pressure chest there will be also pressure above the 6-inch valve disc. Steam is led through this connection to the cruising turbine chest, and passes through the cruising turbine, thereby cooling it. An orifice plate is installed in this cooling steam line to limit the amount of steam bled off. To prevent the passage of steam from the cruising chest through this line when on the cruising combination, a stop-check valve is installed in the line. This stop-check valve is provided with a locking device, and should be locked on "check" at all times except when the cruising turbine is disconnected from the high-pressure turbine. From the case of the valve stem is fitted a lead-off pipe to carry away any leakage past the guide stem and return it to the main condenser.

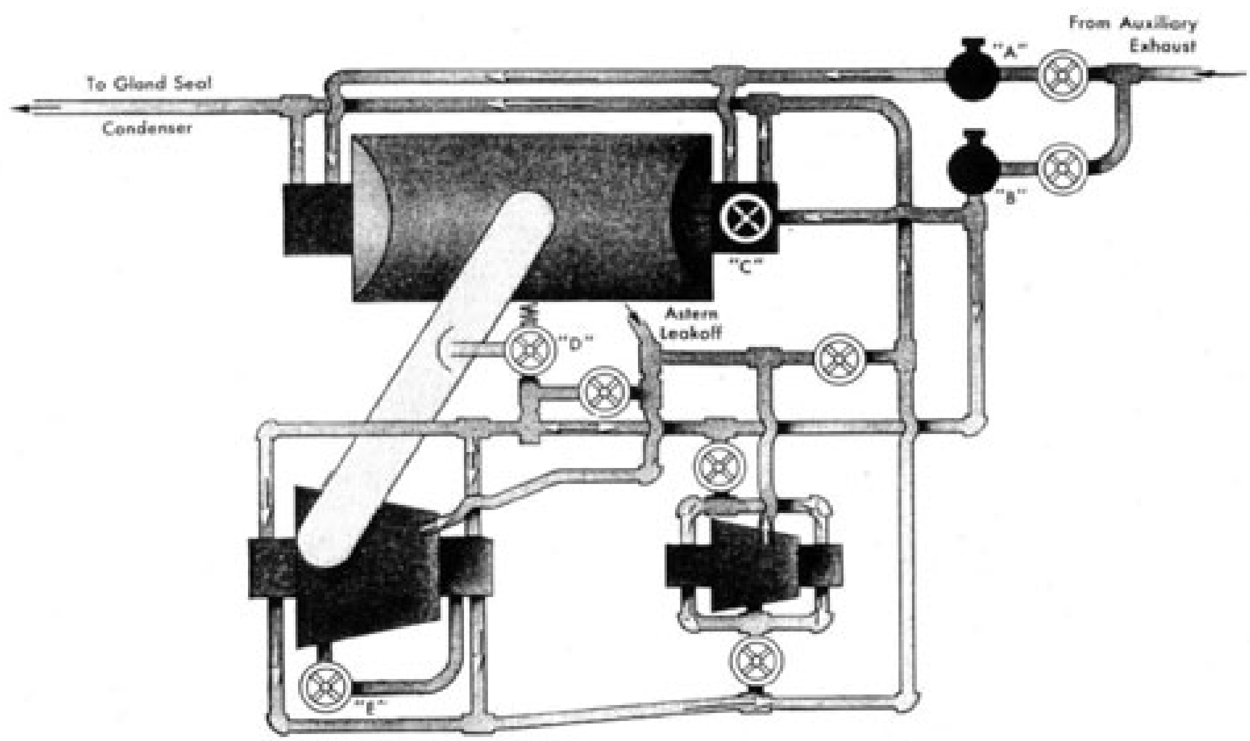
(f) Shifting Combinations.-When on the cruising combination if an increase in speed above the maximum cruising speed is required, it be-comes necessary to shift from the cruising to the high the cruising exhaust pressure should be brought up to a point not exceeding 100 p.s.i. while still maintaining the same speed. At this point it is necessary to shift the cross-over valve and simultaneously close off completely the cruising turbine throttle. This will cause a reduction in speed equal to about the two knots picked up at the beginning of the operation and leave the ship operating with steam going to the high-pressure turbine only. The second method hereafter described is to be used when there are two men at the throttle to make the shift. In this case one man would be stationed at the high-pressure throttle and the other at the cruising throttle and cross-over valve. The man on the cruising throttle should simultaneously close the cruising throttle and shift the cross-over valve. When this is done the man on the high-pressure throttle should immediately open his valve and bring the ship's speed back up to normal. When two men accomplish this shift there will he a loss of speed of only about 10 r.p.m. It should be noted that under no conditions should the cruising turbine exhaust pressure be allowed to rise over 100 p.s.i. Should this occur it will overheat the cruising turbine with consequent damage.

4. GLAND SEALING STEAM SYSTEM

(a) General Discussion-.In order to seal the glands of the turbines and prevent air from drawing through them into the main condenser, steam is passed into the glands to prevent the passage of air. The low pressure turbine, which operates at all times under a vacuum in its casing, must have steam admitted at all times to the glands from some external source. This steam is led from the auxiliary exhaust line, passes through a cutout valve as indicated in figure 44, then through a weight-loaded pressure regulating valve and finally to the turbine glands. This weight-loaded pressure regulating valve operates at all times to maintain a pressure of 3/4 to 1 1/2 p.s.i. to

pressure combination. If this is not properly done, it can easily cause damage to the cruising turbine by overheating. There are two methods which can be used to accomplish this shift. The first method described should be followed when there is only one man available at the throttle to accomplish the shift. In this case, the speed of the ship should be increased about two knots by opening the high-pressure throttle and increasing the high-pressure chest pressure. Then, by simultaneously closing the cruising throttle and opening the high-pressure throttle slowly,

the turbine glands. In the case of the high-pressure and cruising turbines at higher speeds, the pressure on the turbine end of the forward glands will be so great that steam will bleed out through these glands, automatically sealing them. Since these glands may at times seal themselves, it is necessary to have a separate system for the cruising and high pressure turbines. For warming-up and low-speed operation, steam is led from the auxiliary exhaust line through a cutout valve and another weight-loaded valve to the glands of



GLAND STEAM PIPING 445 CLASS
FIG. 44

the cruising and high pressure turbines. Before the inlet to the cruising turbine glands is a valve (fig. 44) which allows steam to be cut out from these glands under certain conditions. This valve is provided with a ferrule over the valve stem to prevent its closure unless it is specifically desired to do so. In warming-up and securing conditions and at low speeds, the weight-loaded valve acts to deliver from 3/4 to 1 1/2 p.s.i. of steam pressure to the glands on both turbines. As speed increases steam will start to bleed from the turbine back into the gland steam line through the forward or high pressure glands. Since part of this steam bleeds into the gland steam supply line it now provides a source of steam for sealing the after or low pressure glands. The weight loaded valve is so constructed that when the pressure in the gland steam line reaches 1 1/2 p.s.i. it will close and admit no more steam from the auxiliary exhaust line. When this condition is reached, then the forward glands are bleeding back enough steam to seal the after glands. As speed is further increased, and we go off the cruising combination, the forward gland of the high pressure turbine is bleeding back enough steam so that the pressure in the gland steam line will rise to excessive heights. A means is provided to unload this excessive steam and maintain a pressure in the line at a reasonable level. Valve *D*, (fig. 44) is an automatically operated spring loaded unloading valve. When the pressure in the gland seal line exceeds 2 p.s.i., this valve lifts and dumps the excess steam into the exhaust pipe from the high pressure turbine, from whence it can be used in the low pressure turbine. As the speed further increases a condition will exist where the high pressure turbine is exhausting at above atmospheric pressure. When the difference in pressure between the inlet and outlet of this unloading valve is less than 2 p.s.i. it will not lift and, therefore, with the pressure at atmospheric or above in the high pressure exhaust pipe, the unloading valve will not operate and the steam pressure in the gland steam line will again start to rise. In order to maintain the pressure still at normal level the needle valve *C* is provided which can be operated to bleed steam from the line directly into the low pressure exhaust. Opening valve *C*, by means of an extension rod to the main

gage board will allow for manual control of the gland steam pressure. At nearly full power the capacity of the needle valve is insufficient to carry away all the excess steam bled back from the forward gland of the high pressure. In order to reduce the amount of steam bled from this gland a line is provided leading from the inner end of the high pressure gland and discharging into the exhaust of the high pressure turbine. Valve *E* in this line must be open when the needle valve, fully open. can no longer control the pressure. For purposes of economy valve *E* can be opened at a much lower speed. If this valve is opened at about 25 knots it will reduce the steam bled back into the gland steam system while still allowing control of the pressure either stopped, backing down, and at speeds up to about 12 knots the weight-loaded valves will, when properly adjusted, automatically deliver proper steam pressure to the glands. At speeds from 12, to 28 knots. pressure should bleed back from the high pressure glands and supply steam to the system causing the weight-loaded valve to close automatically. Somewhere in this range the spring-loaded unloading valve will open dumping excess steam into the low pressure turbine and maintaining the pressure. At speeds from 28 to 34 knots the first manual operation is required. Through this range, it is necessary to control the steam pressure by manually operating the needle valve. From 34 knots to full power it is necessary to open the bypass valve from the high-pressure forward gland and to readjust. setting of the

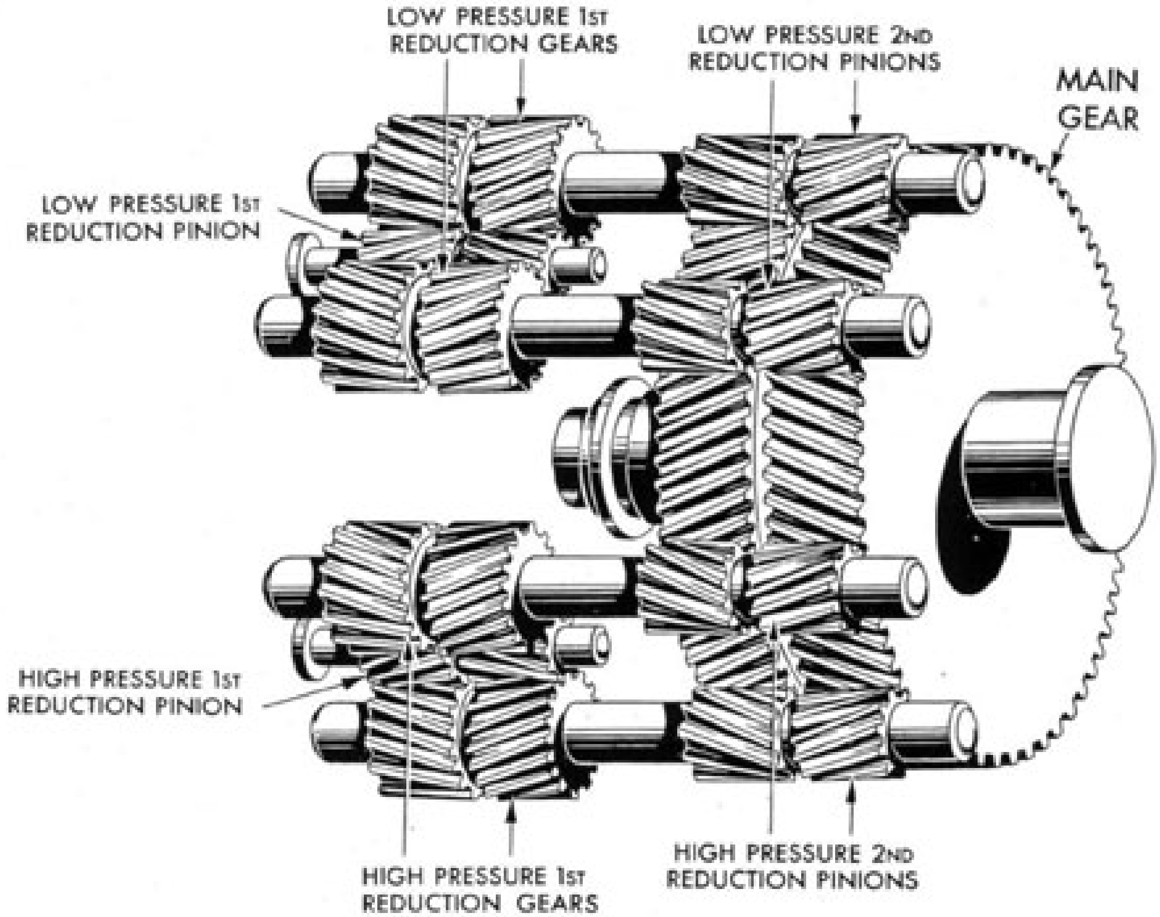
by the needle valve or, if too much steam is bled off, by the weight-loaded supply valve. There is one other source of steam supply to this system and that is from the valve stem leakoffs of the turbine nuzzle control valves and the astern throttle valve. These valves have unpacked stems, and will allow a certain amount of steam leakage. This leakage, bled through a pipe line, can be discharged into the gland steam system or into the gland exhaust system. The gland exhaust system consists merely of a single header which collects the drains from all the glands and leads them to the gland seal condenser which is in the main air ejector shell. A cutout valve is provided at the exhaust from the cruising turbine glands. The gland exhauster takes suction from the gland seal condenser, and allows a slight vacuum to be placed on each of the glands thus drawing out the steam from the glands, and preventing it from exhausting into the engineroom. A large drain pipe is led from the gland exhaust header directly down into the low pressure drain tank. The valve in this line should always be open when operating the gland steam system. If this is not done water will build up in the gland exhaust header and. since there is insufficient vacuum in the gland condenser to drag this water out, it will remain there and prevent the passage of steam through the gland exhaust system. This will cause steam to blow into the engineroom from the glands. When the gland steam system is secured this valve should always be closed to prevent vapor from the low pressure drain tank from passing up into the gland condenser when it is not in operation. A summary of the operation of the steam system shows the following: warming-up, needle valve to maintain the pressure at its proper level. As noted earlier, it is not necessary to wait until this speed is reached to open this valve as it may be opened at as low a speed as 25 knots to gain economy.

(b) DD692 Class.-Arrangement of the gland steam system for the DD692 class is very similar to that shown in figure 44, which is for the DD445 class. In the DD692 class system the spring-loaded unloading valve *D* is eliminated as well as the bleeder valve *E*. The needle valve *C* has been changed to make it a 3 1/2-inch stop valve. This allows for sufficient. capacity of valve *C* to pass any amount of steam which may bleed back into the system. Therefore, when sufficient steam bleeds back to close the weight-loaded valve, valve *C* must, be manually operated thereafter to control the gland steam pressure through all ranges of speeds. In all other respects the system on the DD692 class is the same as shown in figure 44.

5. REDUCTION GEARS

(a) Cruising Reduction Gear.-The cruising turbine is connected to the high-pressure turbine through a single reduction gear. The cruising turbine rotor carries with it a pinion which drives the cruising gear, the cruising gear being coupled to the high-pressure shaft. The speed reduction between the cruising turbine and the high-pressure turbine is 1.779:1. The cruising turbine rotor and pinion are supported by only three bearings, one forward of the turbine and one on each side of the pinion in the reduction gear case.

(b) Main Reduction Gear.-The high-pressure and low-pressure turbines are connected to the main shaft through a locked-train type double



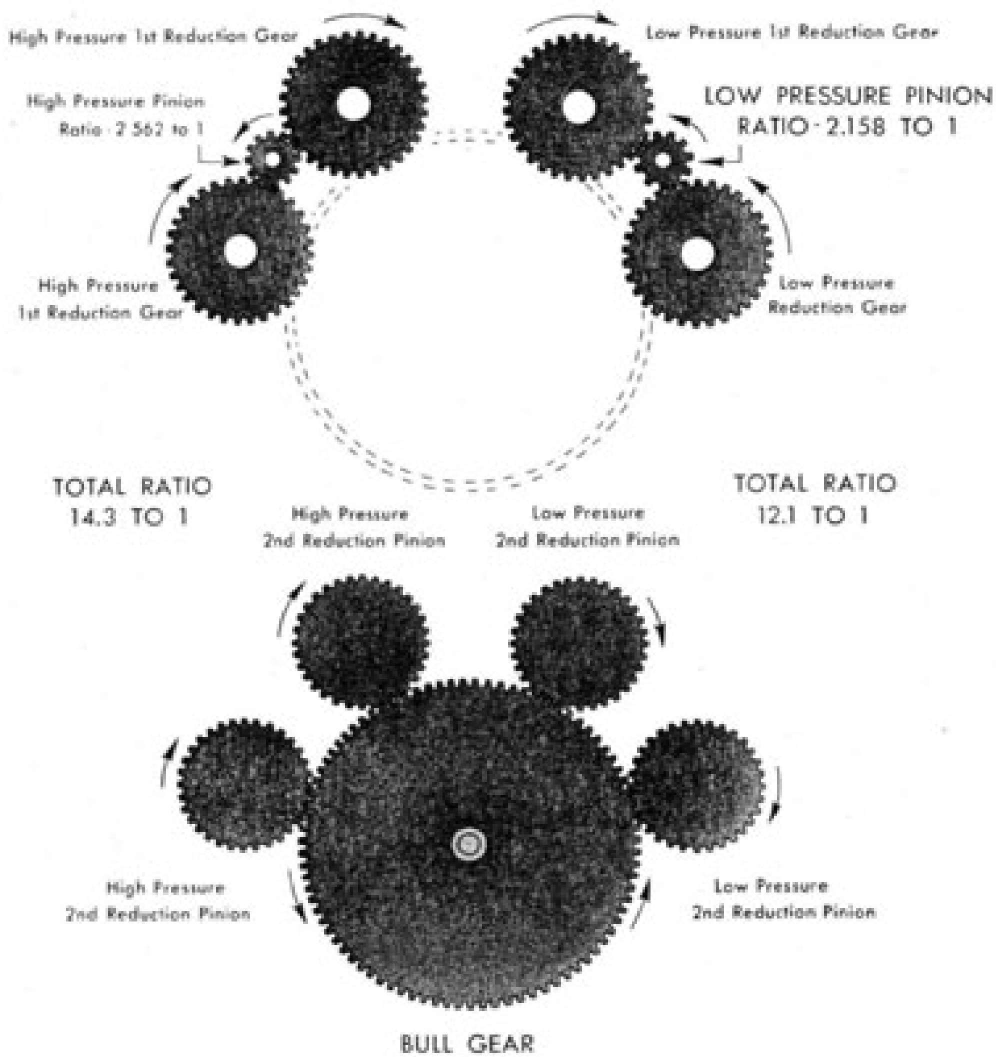
MAIN REDUCTION GEAR
FIG. 45

reduction gear. The arrangement of this gear is as shown in figures 45 and 46. First reduction pinions are connected by flexible couplings to their turbines and each of these pinions drives the first reduction gears. The speed ratio between the high-pressure turbine and the first reduction gears of the DD445 class is 2.562:1 and between the low-pressure turbine and its first reduction gears 2.158:1. This difference in ratio allows the turbines to operate at different speeds while driving the first reduction drive gears all at the same speed. Attached to each of these drive gears (fig. 45) is a second reduction pinion. These pinions, four in all, drive on the main bull gear which is attached to the main line shaft. The total reduction of speed, from the high-pressure turbine to the shaft is 14.3:1, and from the low-pressure turbine to the shaft is 12.1:1. Note that all four second reduction pinions operate at the same

(c) DD692 Class.-The reduction gears of the DD692 class are arranged exactly the same as those for the DD445 class with the single exception that they operate with a different ratio. The maximum r.p.m. of the shaft with these gears is 350 instead of the 397 of the DD445 class while the turbines operate at the same speed. This makes the ratio for the high pressure 16.26:1 and that for the low pressure 13.69:1.

(d) Jacking Gear.-Extending from the end of the high-pressure first reduction pinion, over the bull gear to the after end of the reduction gear case, is a shaft which connects into the jacking gear through a jaw clutch. Engaging this clutch connects the high-pressure pinion to an electric motor through a train of gears, and operating this motor will turn over the high-pressure pinion, causing the reduction gear, line shaft, and all turbines to turn over. The speed of

speed. the motor and the ratio



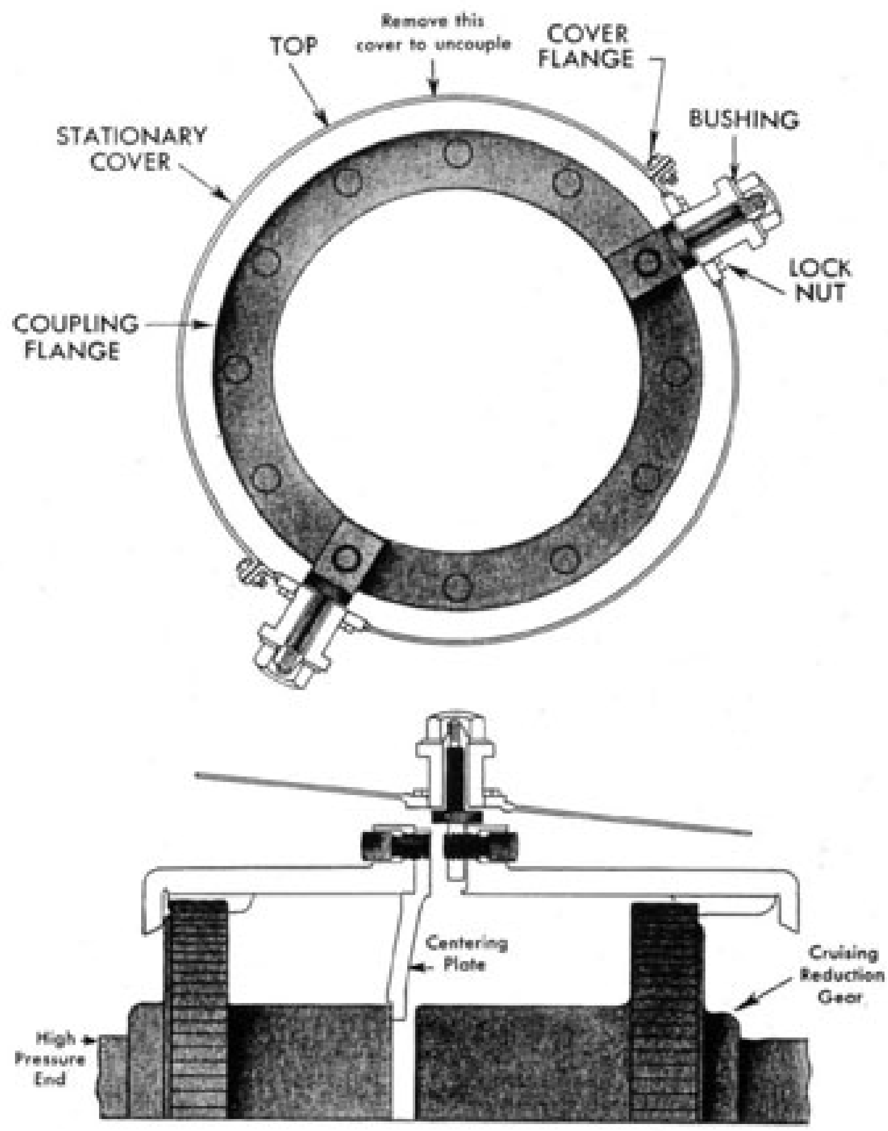
REDUCTION GEAR SECTIONS
FIG 46

of the jacking gear train is such that it will cause one revolution of the main shaft in about 8 1/2 minutes. Between the jacking gear motor and the worm wheel, which drives the jacking gear train, is a coupling. Around this coupling is fitted a friction brake. If the jacking gear clutch is engaged and this brake set around the coupling the main shaft will be held stationary by the jacking gear with the ship going ahead on the other engine. It has been demonstrated that the ship can go ahead at full power on one engine with this brake in operation, and the idle shaft will either by stopping the ship or by holding the engine stationary with the astern turbine. The clutch should never be engaged underway without also using the brake and continuing oil circulation to the bearings. The gear ratio between the electric motor and the main shaft is about 16000:1 and should the shaft turn over 1 R.P.M., the motor would undoubtedly burn out.

(a) Cruising Turbine Disconnecting and Locking Device.-In case of a casualty to the cruising turbine the coupling between the high-pressure turbine and

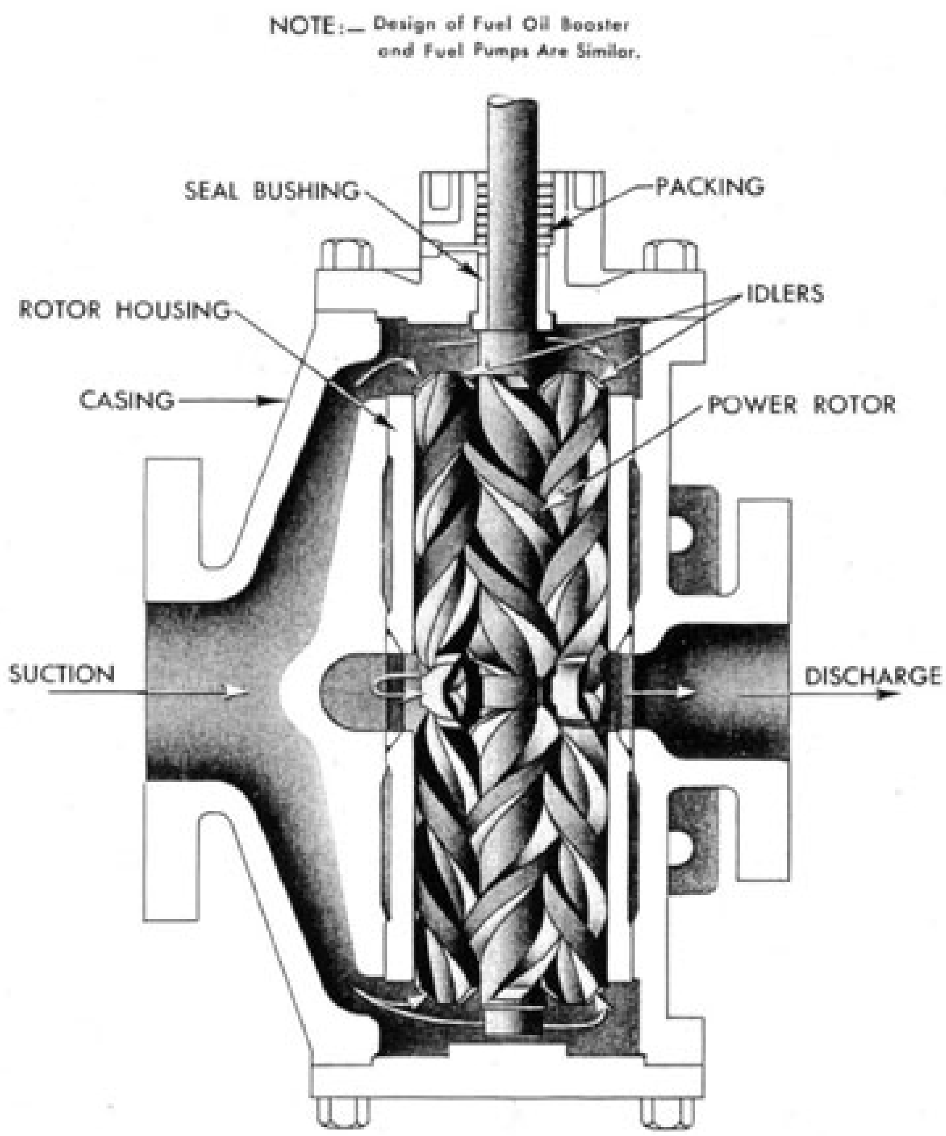
be prevented from turning over. In order to engage the jacking gear clutch it is necessary to first stop the engine

the cruising turbine reduction gear may be disconnected to allow for operation of the high-pressure turbine without rotating the cruising



CRUISING TURBINE LOCKING DEVICE
FIG. 47

turbine. Figure 47 is an illustration of the gear necessary to be installed when this coupling is disconnected. The upper half of the cover over the coupling is first removed, exposing the coupling. Welded into the lower half of this cover are two pads with tapped boles in them. Both pads are in the same half of the cover, and are about 150 degrees apart. Also, since the cover is bolted to the high-pressure turbine casing, they are stationary. With the coupling disconnected. the high pressure half of the coupling sleeve will be loose on the high-pressure shaft, and rotation of the high-pressure turbine will cause it to flop around and unbalance the high-pressure rotor. To prevent this, three centering plates are provided, machined to provide an exact fit as shown in figure 47. These are held to the coupling sleeve by Allen-head tap bolts through the flange and, butting against the shaft end, center the high-pressure coupling sleeve and hold it rigid. With the cruising turbine not held stationary by some means, it might be turned over occasionally, due to the windage set up by rotation of the high-pressure half of the coupling. In order to lock the turbine stationary, the pins (fig. 47) are inserted through the pads in the coupling cover previously mentioned.



PUMP END - LUBE OIL SERVICE PUMP
FIG. 48

The end of the pin is attached to the cruising turbine half of the coupling case by an Allen-head tap bolt and it is centered in the pad by a bushing. The whole assembly is drawn into place and the coupling case centered by adjusting the nuts on the top of the pin. An inspection of these pins (fig. 47) will illustrate the method b which they are installed. When this gear is fully installed, the upper half of the coupling cover should be replaced to prevent rotation of the high-pressure half of the coupling in the open.

6. LUBRICATING OIL SYSTEMS

(a) Main Lubricating Oil Pumps.-Each engine room is provided with two main lubricating oil pumps, the purpose of which is to deliver lubricating oil at the proper pressure to the main turbine bearings and to the reduction gear bearings and sprays. On some of the earlier installations of the DD445 class, one of these pumps is electrically driven and the other steam-driven. On later installations of the DD445 class and on all of the DD692 class two steam-driven lubricating oil pumps are provided. The DD692 class ships

on which the piping could be changed during the building period are being equipped with an additional main lubricating oil pump in each engine room, chain driven from the main shaft. These pumps are all positive displacement rotary pumps of the general design shown on fig. 48. The center gear is the power rotor which meshes with and drives the two idler rotors. These rotors are double-ended as shown in figure 48 and the suction passage is so arranged that oil flows to both ends. There the oil is entrained by the worm-like threads of the rotors and driven toward the common discharge connection at the center of the unit. The major quantity of oil is pumped by the power rotor, the idlers serving primarily as seals although they do pump a small quantity of oil. The clearances held between the rotors and their housing are such that leakage past the threads is held to a negligible amount. In the actual installation a pin is installed at the base of each idler to provide support when the pump is not in operation. These pins have been left out of figure 48 to make the double suction of the pump more apparent. Where an electric pump is provided the electric motor and pump operate at service will furnish the primary supply of oil to the headers augmented by the supply from the chain driven pump above approximately 40 shaft r.p.m. The sprockets driving the chain driven pump are designed to have these pumps, which are identical with the steam-driven pumps, deliver rated capacity when the main shaft is turning at 350 r.p.m. A one-eighth inch orifice through the seat of the steam driven service pump governor valves is provided to furnish sufficient steam to the selected stand-by service pump turbine to assure that the pump is warmed up, turning over at slow speed (about 40 r.p.m.) and will immediately pick up the load as the main shaft is slowed, stopped, or when going astern. This arrangement assures that normal bearing and spray header pressure will he maintained irrespective of the speed at which the main shaft is turning. Either one or both of the steam-driven service pumps may be lined up as stand-by during various conditions of operation. For normal service one steam-driven pump will be in operation in each engine room and the other pump secured.

(b) Leslie Constant Pressure Pump Governor.-To control the discharge pressure of the steam pumps a Leslie constant pressure pump governor is installed in

the same speed, approximately 1,150 r.p.m. The steam pumps are driven by a horizontal turbine through a reduction gear consisting of a worm gear and worm wheel. The arrangement of this driving gear is very similar to that described in connection with the main condensate pump, section IV, paragraph 3. The gear case acts as the oil sump tank, and an attached oil pump geared from the worm wheel takes suction from this sump and discharges oil through an attached cooler to the bearings. A limit speed governor of slightly different design than that on the main condensate is also provided. The basic principle of operation of this governor is the same but the total travel of the governor valve should be adjusted for three-eighths of an inch. This governor varies the opening of the steam control valve, closing it down as the pump tends to overspeed and maintaining the pump limit speed at about 1,165 r.p.m. The normal rated speed of the pump is about 1,150 r. p.m.

The chain driven pumps noted above are arranged to furnish the primary supply of oil to the bearing and gear headers at full power, with one or both of the steam driven lubricating oil service pumps as stand-by. At low power operation the steam driven lubricating oil pump selected for

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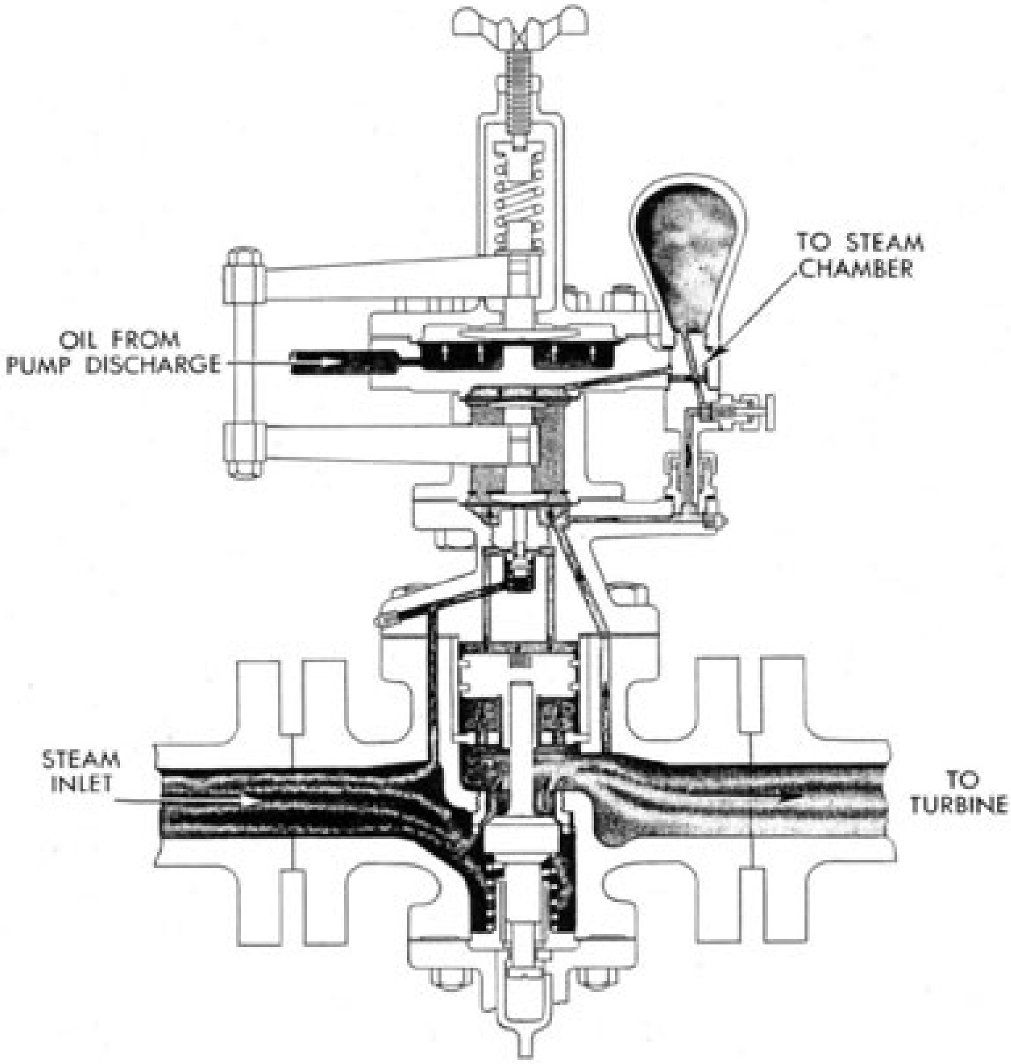
the steam line to each pump. This governor operates on the same basic principle as the Foster pump governor discussed in section V, paragraph 4. That is, a change in capacity requirement of the pump is reflected by a momentary change in discharge pressure. This change in discharge pressure causes adjustment of a pilot valve within the governor and consequent change in governor valve opening to restore the pressure to normal. In the Leslie governor (fig. 49) the pump discharge pressure is led through an actuating line to the space below a single diaphragm located in the top of the unit. The pump discharge pressure exerts an upward force on this diaphragm. To balance this force a spring is placed above the diaphragm which exerts its force on the diaphragm through the arrangement of crosshead and mushroom shown. As in the Foster governor it is the balance of these two forces which controls the operation of the governor. With the spring force greater than the upward force, the diaphragm will be displaced downward. This means the upper cross head will also move downward carrying with it the connecting rod and lower cross head. This will cause the lower cross head to press against the lower diaphragm



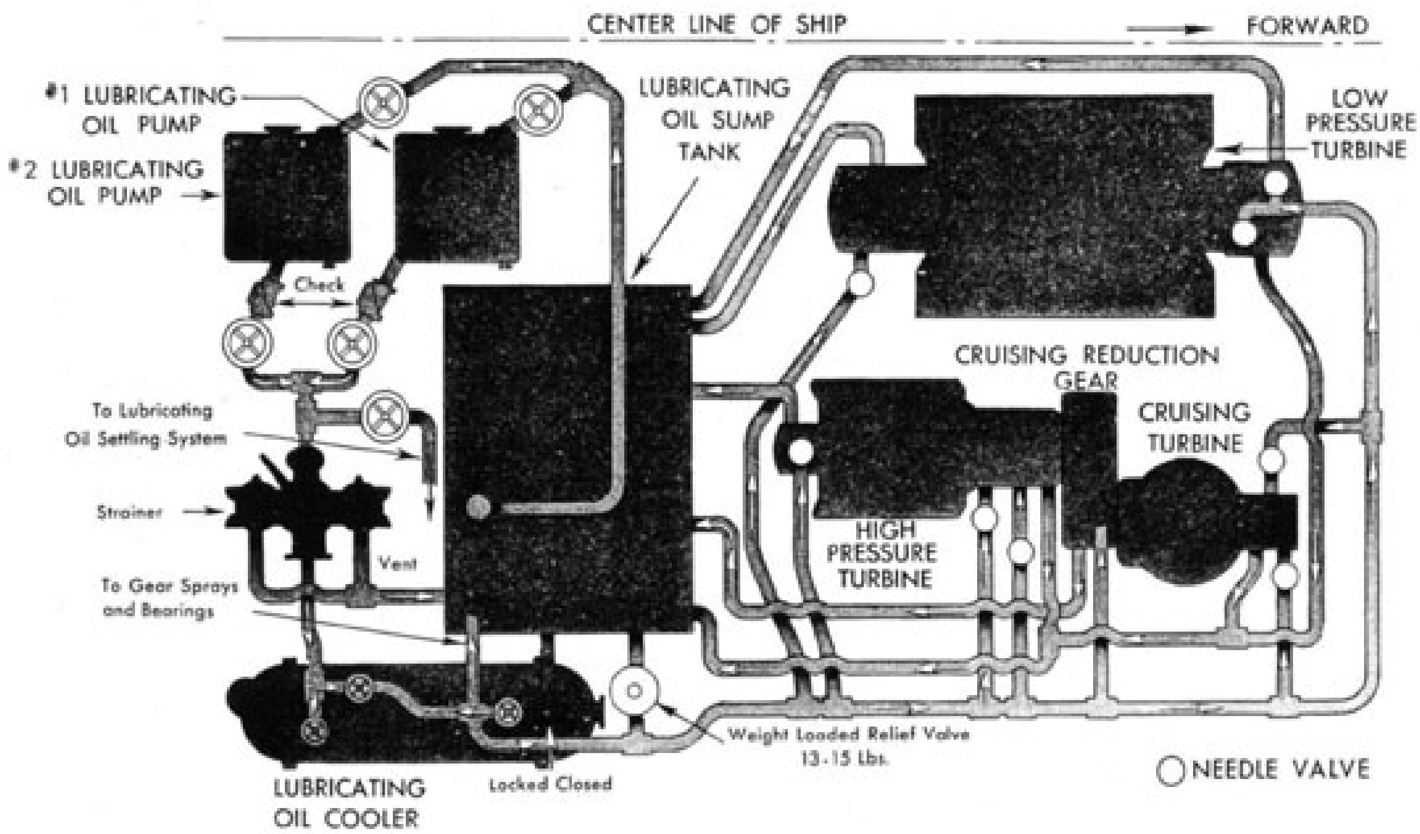
LESLIE CONSTANT PRESSURE REGULATING VALVE
FIG. 49

through the mushroom shown, thereby displacing it downward. Since the lower diaphragm is in contact with the pilot valve stem this will cause the pilot valve to be opened. The pilot valve is always supplied with steam from the inlet side of the governor valve and when it is opened steam passes through two ports to the top of the operating piston. The steam pressure exerted on the top of operating piston forces it down and opens the governor valve, admitting steam to increase the pump speed. This increase in speed is reflected by an increased discharge pressure from the pump. When the pressure has increased sufficiently so that the upward force on the upper diaphragm is greater than the spring force the diaphragm is displaced upward. This causes a reduction in the pilot valve opening and allows a spring to close the governor valve against the now reduced pressure on the operating piston. As in the Foster governor, the oscillations are so rapid as to be reflected in a constant discharge pressure if all elements of the unit are properly adjusted. Means is provided to vary the tension on the adjusting spring. Increasing the tension will require a higher discharge pressure to restore the balance on the diaphragm and lowering the tension will produce a lower discharge pressure. The means employed in this governor to reduce

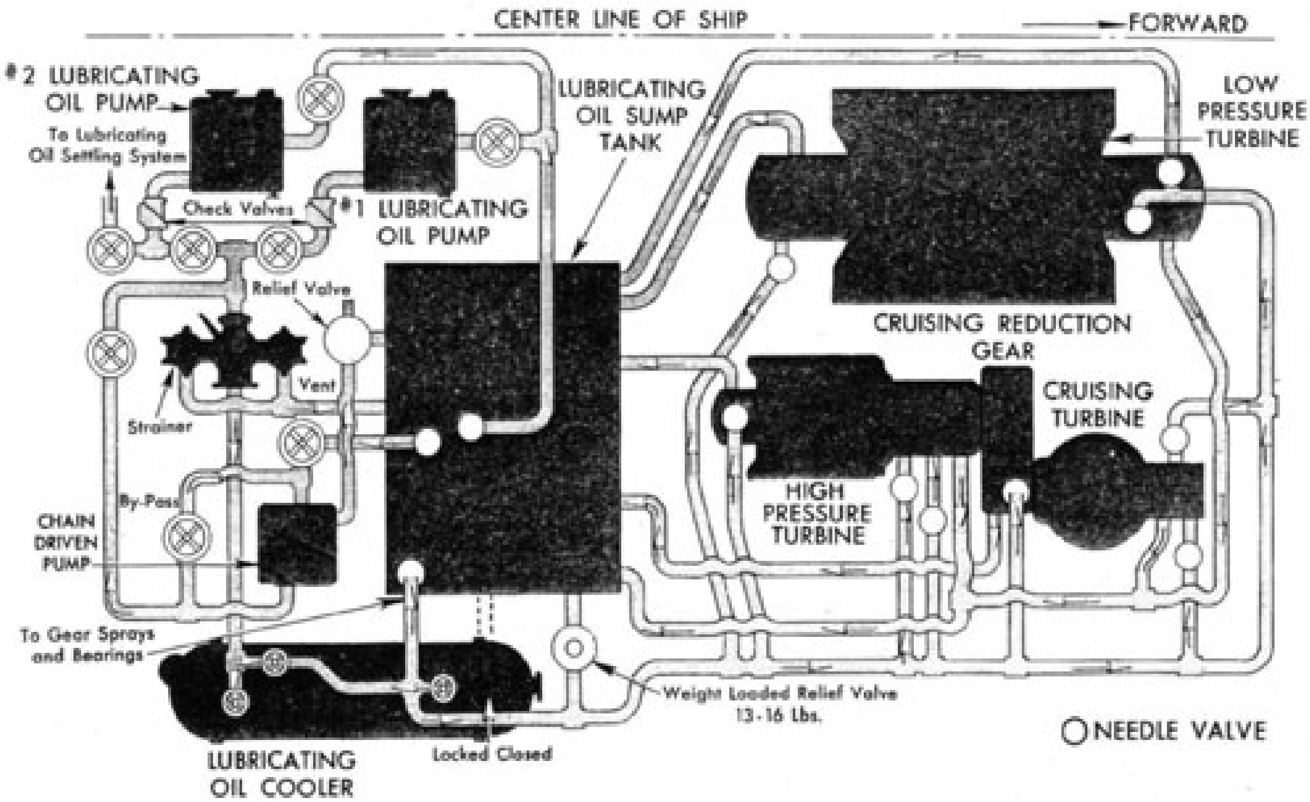
the "hunt" differs from that employed in the Foster governor. An intermediate diaphragm is inserted, bearing against the top of the lower yoke through another mushroom. Steam is led from the governor valve outlet to the bottom of the lower diaphragm and from there through a needle valve to the top of the intermediate diaphragm. Thus it can be seen that any movement of the lower yoke, either tip or down, will be opposed by the force of the steam pressure on the intermediate or the lower diaphragm. This will reduce the amplitude of the oscillations of the pilot valve and consequently reduce the "hunt" of the governor. The needle valve regulates the amount of steam going to the intermediate diaphragm. If it is not properly adjusted the governor will have excessive "hunt" and "regulation." Experience has shown that, in general, opening the needle valve from one-half to three-fourths of a turn will provide satisfactory operation. However. adjustment should be made by experiment to suit the particular governor. The steam chamber (fig. 49) continuously provides proper pressure to the intermediate diaphragm although the space above it may be filled with water from condensation. Below the governor valve a valve stem is fitted which, when operated, draws the governor valve wide open permitting a full flow of steam to the turbine. This will require that the turbine speed be controlled by hand throttle. There are two positions for this valve stem, "auto" and 'manual." Under normal operation the stem should be set on "auto" to allow control of the pump by the governor.

(c) Steam and Electric Pump Interlock.-The early DD445 class installations were provided with an electric lubricating oil pump and a steam lubricating oil pump per engine. They were designed to operate with the pump discharge pressure 35 p.s.i. Before reaching the bearings, this pressure was reduced by means of an orifice being actuated by an actuating line which leads directly from the steam pump discharge casing. This switch is so adjusted that. when the pressure discharged from the steam pump drops to 25 p.s.i., the cut-in switch makes contact and automatically starts the electric pump. With the electric pump in operation, if the steam pump discharge pressure is brought up, the contact breaks and the electric pump is automatically shut down. This cut-out pressure should be set as high as possible to prevent the danger of the pump shutting down due to its own pressure. This automatic feature of the electric pump will only be in operation when the switch on the electric pump controller is set in the automatic position. Note that the electric pump cuts in and cuts out only on a change in pressure of the steam pump. The actuating line to the Leslie constant pressure pump governor leads from the lubricating oil line before the orifice plate, the orifice plate being located at the strainer inlet. In this manner we have pressure in the actuating line to the Leslie governor no matter which pump is in operation. If the governor is then set for 30 p.s.i. and the electric pump is operating at 35 p.s.i., this actuating pressure in the Leslie governor will hold the governor valve closed. However, should the electric pump pressure drop below 30 p.s.i., for whatever reason, the Leslie governor will open and admit sufficient steam to the steam pump to run it at a speed which will maintain the 30 p.s.i. pressure in the actuating line. If the electric pump is operating normally we could then leave the steam pump lined up and it would act as a standby to take up the load in case of a casualty to the electric pump. However normal underway operation is with the steam pump in use, and the electric pump standing by with its controller set on automatic. With this set-up if the steam pump discharge pressure should fall to 25 p.s.i. the electric pump will automatically start up and restore the pressure to normal. In doing this, the actuating pressure to the pressure regulating valve, will return to normal and remain there, causing the regulating

plate and a weight-loaded relief valve to the normal bearing pressure of 10 p.s.i. The 35 p.s.i. pump discharge pressure was necessitated by the presence of the main turbine overspeed governor valve. This governor valve has since been removed from or made inoperative in all installations, but since the electric pump and the Leslie governor were designed for 35 p.s.i. it was necessary to retain 35 p.s.i. pump discharge pressure. In these installations the electric pump is equipped with an automatic cut-in and cut-out switch, this switch valve to shut off steam to the steam pump and stop it. To make this set-up work most efficiently both ways the Leslie governor should normally be adjusted for a discharge pressure of 30 p.s.i. and the recirculating valve, from the electric pump discharge back to the lubricating oil sump tank, should be open to maintain the electric pump discharge at 35 p.s.i.



DD445 CLASS
MAIN LUBRICATING OIL PIPING
#1 ENGINE ROOM
FIG. 50



DD 692 CLASS
MAIN LUBRICATING OIL PIPING
#1 ENGINE ROOM
FIG. 50A

(d) Steam Pumps-Interlocks.- Where two steam-driven lubricating oil pumps are installed the Leslie pump-governor, designed to operate at a lower pressure, has also been installed. This allows for the removal of the orifice plate. The actuating line for the Leslie valves in this installation comes, not from before the strainer, but from the lubricating oil line beyond the lubricating oil cooler. This allows the Leslie governor to operate the pump at a speed which will maintain the proper pressure at the bearings, and no other control of pressure is needed in the lubricating oil line. It is possible with these two governors to set up the pumps so that one will stand by for the other. If one governor is adjusted for a discharge pressure of 10 p.s.i. and the other for a discharge pressure of 8 p.s.i., the 10 p.s.i. pump will operate and the 10 p.s.i. of actuating end the oil flows aft for a foot or so and then divides. One line leads to the main reduction gear oil header to supply oil for the reduction gear internal system. The other line leads forward past the weight-loaded relief valve and provides the main bearing header for the turbines. From this main bearing header are led all the oil supply lines to the main turbine bearings and thrust bearings. Before entering each bearing, the oil passes through a needle valve, adjustment of which will regulate the amount of oil delivered to each bearing. These needle valves are so constructed that they cannot cut off fully the flow of oil to the bearing. Their normal adjustment is in a position which is about half way between their fully open and fully closed position. With this adjustment the turbines should operate at full power with a rise in temperature of oil through the bearings of approximately 20 degrees F. In case a bearing is

pressure working on the Leslie valve set at 8 p.s.i. will hold that valve closed and allow no steam to enter its turbine. If, due to a casualty to the 10 p.s.i. pump the actuating pressure drops to 8 p.s.i., the 8 p.s.i. pump will be started by the Leslie valve to act as a booster or to take over the full load at 8 p.s.i. should the 10 p.s.i. pump stop entirely. Either pump can be adjusted for 10 p.s.i., with the other at 8 p.s.i.

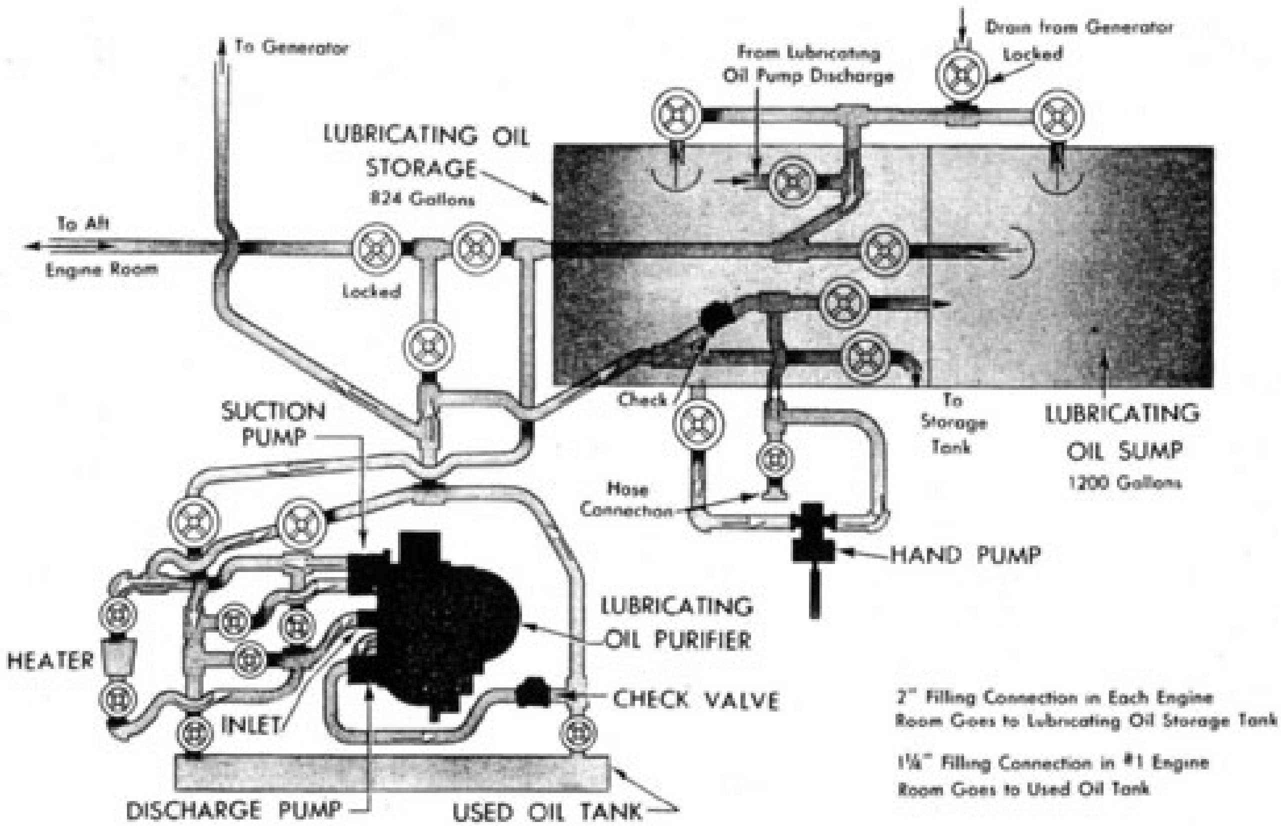
(e) Lubricating Oil Supply System.-T his system supplies oil under pressure to the reduction gears and to all main turbine bearings for the lubrication of these gears and bearings. Figure 50 shows the arrangement of this system. This arrangement is for all installations in the DD445 and DD692 classes in which two steam lubricating oil pumps are installed. Where one electric and one steam pump are installed the only difference is that a 3 1/4-inch orifice plate is located just before the strainer and the weight-loaded relief valve lending from the main bearing header is adjusted to start lifting at 10 p.s.i. The two lubricating oil pumps take suction from the bottom of the main reduction gear case which acts as a lubricating oil sump tank. Oil from here is discharged, through a check valve after each pump, through a discharge cut-out valve and finally into a common discharge line which leads through the strainer. The strainer is a double-barrelled strainer which is capable of having the flow shifted from one barrel to the other for cleaning purposes. From the strainer the line leads to the top of the lubricating oil cooler, through a valve there and into the cooler. Leaving the cooler at the opposite wiped the enlarged oil clearance might rob other bearings in the system. The needle valve opening can be reduced to prevent this. Should a needle valve become fully closed it will still allow sufficient flow of oil to the bearing to allow for operation at full power with a rise in temperature of 50 degrees F. to that hearing. The drain system from the bearings consists of a separate drain from each of the after bearings of the low pressure and high pressure turbines. The drains from the forward and thrust bearings of all three turbines are collected by a single header. All these drains lead directly into the lubricating oil sump tank. The cruising turbine reduction gear which is also supplied with oil from the main bearing header, drains to the sump tank through a separate drain line. A branch line lends from before the lubricating oil strainer and joins with the lubricating oil purifying and settling system to allow for bleeding oil from the supply system for purification. A bypass is provided around the cooler. From the base of the cooler is led a drain line which discharges into the sump tank. The valve on the base of the cooler is fitted with a lock, and should be at all times locked "closed." The major purpose for using this drain line is when it is necessary to heat the oil. By putting exhaust steam in the cooler before pumping oil to the bearing, oil can be circulated through the cooler back to the sump tank and heated.

(f) Special Notes.-To provide proper lubrication of the bearings even though the engines are merely jacking over it is essential that the oil

temperature be at least 90 degrees F. when pumping to the bearings. Oil should always be pumped to the bearings when the turbines and gears are being jacked over or when the, jacking gear is being used under way to prevent the shaft from turning over. Except as noted above, it is not desirable to pump oil to the bearings unless the engines are being jacked over. When securing, under no circumstances should jacking of the engines be stopped until the oil temperature has dropped to at least 100 degrees F. When securing, cooling water to the oil cooler should be secured as soon as possible to prevent too rapid cooling of the oil. Should the main reduction gear be allowed to cool too rapidly, a great deal of condensation will form in the reduction gear case. This will cause rusting of the gears as well as cause water to be collected with the oil in the sump tank. In order to reduce this amount of condensation to a minimum it is necessary to continue jacking the engines for at least two hours after securing the vacuum in the main condenser, allowing the oil temperature to cool down very slowly and never allowing it to drop below 90 degrees at any time. This operation will allow reduction gears to cool down slowly enough to prevent the condensation which would occur if cooled rapidly.

(g) Lubricating Oil Purifying and Settling System.- In addition to the lubricating oil supply system, a purifying and settling system is installed which will allow for the transfer of oil from one plant to the other and also allow for purifying of the lubricating oil in both engine rooms. A lubricating oil purifier is provided in each engine room in order to separate impurities and water from the oil. In the forward engine room the lubricating oil settling tank is installed on the upper level but there is none in the after engine room. Figure 51 shows the lubricating oil settling and purifying system in the forward engine room as installed in all DD445 and DD692 class ships. By referring to this drawing it can be seen that the purifier can take suction from either the sump tank, the storage mentioned, joins into this same suction line. The purifier suction pump discharges through a lubricating oil heater the purpose of which is to heat the oil to a proper temperature (160 degrees F.) before it enters the purifier bowl. A bypass line leads from the purifier suction pump discharge directly into the bowl for use when desired. Another bypass leads from the suction line directly into the bowl, bypassing the suction pump. When purified, the oil passes from the bowl to the purifier discharge pump and is pumped into a discharge line. This discharge line leads to the lower level with branches into the storage tank, the sump tank, and back to the generator. A branch also goes to the settling tank. In addition to these places the discharge line from the purifier leads to a cross-connection line which passes through the bulkhead and joins this system in the other engine room. At the bulkhead is a locked valve to cut out this cross-connection, which should be locked at any time the line is not in use. The same cross-connection line leads also into the purifier suction line so that we can either discharge through this line into the other system or take suction from the other system through this line. In order to allow for rapid transfer of lubricating oil from the storage tank to the sump tank or to the other system, a line is provided leading directly from the purifier suction pump discharge line into the purifier discharge line. This bypasses the entire purifier with the exception of the suction pump. However, the capacity of the purifier bowl is so nearly equal to the capacity of the suction pump that no advantage will be gained by not putting the oil through the purifier bowl when transferring. The after system is, of course, on the opposite side of the ship but, with the exception of the lubricating oil settling tank and its connection, it is arranged in exactly the same manner as the forward system. Filling lines for the lubricating oil systems are provided in each engine room to the storage tank only. In addition, in the forward engine room a filling line is provided leading to the lubricating oil settling tank. It is not possible to fill directly into the sump tank. To do so it would be necessary either to

tank, or the generator sump tank. Also a suction is provided to the bull-gear oil pan on DD445 class ships. All of these suction leads join together in a common line which leads to the suction pump of the purifier. This line also leads past the purifier into the lubricating oil settling tank, which allows the purifier to take suction from the settling tank itself. The branch from the lubricating oil service system, previously pump the oil from a storage tank into the sump tank or allow the storage tank to overflow into the sump tank when filling. Since the storage tanks vent into the sump tanks it is possible to fill them to 100 percent of capacity as expansion of the oil would cause it to overflow only into the sump tank and would not put a



LUBRICATING OIL SETTLING AND PURIFYING
#1 ENGINE ROOM
FIG 51

pressure on the storage tank. Navy symbol 2190T lubricating oil should be used in the main and generator lubricating oil systems.

(h) Procedure in Case of Loss of (or Low) Lubricating Oil Pressure.-Buships Ltr. S41-1 (641-640-800) over S42 over EN28/A2-11 of 25 October 1944. is quoted herewith in part:

2. Extensive derangements of main propulsion machinery have resulted from the loss of lubricating oil pressure. In many instances the loss of lubricating oil pressure has been due to improper operational procedure rather than material failure; and the resulting damage has been unnecessarily extended by the following unsound procedures:

(*a*) Partial checking of shaft speed, instead of stopping shaft rotation.

(*b*) External examination of bearings including check of sight flows and temperatures, which usually appear to be normal, rather than thorough examination.

(*c*) Resumption of operation, with aggravation of the damage.

3. It must be Impressed on all personnel concerned that:

(*a*) Even momentary loss of flow of lubricating oil will result in localized overheating and probable slight wiping of one or more bearings although only a momentary, moderate rise may occur in the temperature of lubricating oil discharge from the bearing(s).

can be prevented by prompt action of the throttle-men in closing their throttles when steam pressure drops below a selected pressure and by slowing down auxiliary machinery, thus conserving the available steam for the lubricating oil pumps and vital auxiliary machinery and providing time to open cross-connection valves when it is safe to do so.

8. The lubricating oil low pressure alarm should be adjusted to sound at the lowest safe operating pressure for full power operation, as stated in the Main Propulsion Machinery Instruction Book.

9. *General procedure for low lubricating oil pressure condition.*

(*a*) On sounding of the low pressure alarm or other indications of loss of oil pressure, immediately stop the affected shaft and simultaneously endeavor to regain lubricating oil pressure.

(1) If the steam pressure is available close the throttles in use and stop shaft by use of astern throttle, or vice versa. Engage the jacking gear and apply jacking gear brake if provided. If speed is in excess of one-half full power speed it may be necessary to slow down the vessel in order to stop the shaft and engage the jacking gear. While shaft is turning, keep continuous check on gages and sight glasses, watching for a reduced or interrupted flow. Listen for and endeavor to locate the source of any unusual or abnormal sounds. After securing the affected shaft, the ship's speed may be increased to the limit for lock-shaft operation.

(2) If steam pressure is lost in one engine

(b) Stopping shaft rotation and restoring lubricating oil flow as rapidly as possible will prevent or minimize damage.

(*c*) Operation on wiped bearings will cause serious derangement to the shaft packings, oil seals, and blading.

4. Operating personnel must thoroughly understand the precautions and the procedures to prevent low lubricating oil pressure, and also be trained in a sound procedure should this serious condition occur.

5. Loss of lubricating oil pressure may be caused by:

(*a*) Failure of the system itself, including the main lubricating oil pumps.

(*b*) Failure of power supply steam or electric, to the main lubricating oil pumps due to an operational casualty or damage to boilers, steam lines, or electrical equipment.

6. Failures of the system may be caused by presence of dirt, rags, or other foreign material due to improper cleaning; to a piping failure: or failure of the operating pump, coupled with failure of the stand-by pump to start (or to be started). Stand-by pumps shall be maintained ready to start the moment the pressure drops below the prescribed operating range. Where automatic starting devices are not provided on steam-driven pumps, the pumps shall be lined up so that opening the throttle is the only action required to start the pumps. Steam supply lines to standby pumps shall be drained continuously. Where electrical pumps are room during split-plant operation and unless the tactical situation positively prevents, take way off ship by backing other engine(s). Concurrently determine the nature of the casualty or damage causing the loss of steam. If it will not cause loss of steam to the other plant, open auxiliary and main steam cross-connections immediately. If damage would cause loss of steam to other plant, isolate damage and then open auxiliary and main steam cross-connections as soon as practicable. Stop and lock the affected shaft as soon as steam is available.

(3) Concurrently, make every effort to regain lubricating oil pressure:

(a) Check lubricating oil pump in use. If not operating, start stand-by pump.

(b) Shift duplex strainers.

(c) Check sump level. If low, replenish oil.

(d) Locate and repair any leaks.

(*b*) Concurrently with the above steps, inspect all bearings and endeavor to determine which have been overheated. Do not rely on thermometers alone. A thermometer may have indicated only a slight, unobserved, momentary rise.

(*c*) Secure gland sealing steam and the main air ejectors (air pumps) to minimize main turbine rotor distortion.

(*d*) Inspect and clean lubricating oil strainer basket not in use. Note whether flakes of bearing metal are present in strainer.

(*e*) Start lubricating oil purifier if not in use.

installed personnel must be thoroughly familiar with alternate sources of power.

7. Loss of steam pressure due to battle damage may be unavoidable. Split-plant operation is prescribed when maximum damage control is required to prevent total loss of power; therefore cross-connection valves between split-plants must not be opened until damage is isolated. Complete loss of steam pressure due to operational casualties such as low water in boilers or water in fuel oil usually

(*f*) Continue circulation of lubricating oil until bearings are sufficiently cool for inspection and maintain the

lubricating oil system in operation at all times except when inspecting bearings so that lubrication will be provided if shaft-locking gear should fail.

(*g*) Take bearing-wear micrometer readings of all bearings and axial clearances where means are provided.

(*h*) Proceed with the inspection of bearings. Raise bearing caps and roll out shells. The inspection must be as thorough as circumstances will permit, realizing the importance of subsequent reliable performance and weighing it against the time required to inspect suspected bearings.

(*i*) It is possible that the bearing trouble is isolated and only one or a few bearings are wiped. It is realized that a thorough examination of the main reduction gear bearings may not be practicable immediately following such a machinery derangement, but the following procedure is recommended:

also wiped, and the shaft should not be operated until such time as proper inspections and repairs can he made.

(*j*) The Bureau desires to emphasize that when operation is resumed after a shaft has been locked for several hours the turbine rotors are probably bowed, and steps must be taken to correct this condition. If the tactical situation will permit. the ship should be stopped and the engine warmed up in the routine manner. If such is not permissible, and it is not desired to proceed on the remaining engine(s) to a location where the engine can be warmed up in the routine manner, the ship should be slowed to the minimum allowable speed, and the following procedure followed:

(1) Admit steam to the astern throttle to remove or ease strain from the jacking gear and to prevent the shaft from rotating at such speed as to cause vibration.

(2) Unlock the jacking gear shaft locking device (if fitted).

(1) All turbine and cruising reduction gear bearings should be thoroughly inspected.

(2) Main reduction gear bearings that are accessible without lifting the gear casings should be thoroughly inspected. Inaccessible main reduction gear bearings should be examined through inspection openings for flow of babbitt along the shaft.

(3) Reduction gear bearing thermometers should be removed to check for oil flow from the wells. Absence of oil flow from a well indicates that the bearing may be wiped to the extent that the oil passage to the thermometer has been closed. When such a condition exists, a below normal reading would be shown by the thermometer when the shaft is operating. Also there may be a stoppage of oil to the bearing.

(4) The oil strainer basket in use should be examined for the presence of babbitt flakes.

(5) If examination of main reduction gear bearings shows no indications of wiping and only one of the turbine and cruising gear bearings is found to be wiped, the main reduction gear bearings may be assumed to be undamaged, and the shaft may be operated at the minimum speed which the tactical situation will permit until such time as a thorough examination of the main reduction gear bearings can be made by tender or yard repair forces.

(6) If several of the turbine and cruising reduction gear bearings are found to be

(3) Disconnect the jacking gear (if fitted) or shaft-securing device.

(4) Simultaneously with the above cut in the gland sealing system and one stage of the main air ejector (or approximately 20" vacuum if main air pumps are installed).

(5) Crack the ahead throttle to provide a feather of steam to equalize heating of the rotor.

(6) Ease the idle shaft by slowly closing the astern throttle, keeping the shaft speed below the sensible vibration speed. During this operation the turbine rotors are heated by the equalizing steam flow (subpar. 9 (*j*) (5) above) and windage, will gradually straighten themselves without damage. If the installed thermometers have sufficient range, the observed temperature of the exhaust should not be permitted to exceed 450 degrees F. During this period the main condenser must be cooled normally (scoop or main condenser circulating pump).

(7) When the idle shaft has been eased up to its free dragging speed the full vacuum should be raised and the engine should be reported ready.

(*k*) Before disengaging a locked shaft the temperature of the main steam should be reduced as much as practicable. In ships equipped with superheat control boilers the superheater burners in time affected plant should be cut off.

wiped. It is probable that some of the main reduction gear bearings are

Section VIII

MISCELLANEOUS SYSTEMS

1. AUXILIARY STEAM SYSTEM

(a) General Discussion.-The auxiliary steam system in both the DD445 and DD692 classes consists of a complete loop through each plant so arranged that both loops can be connected together to form a complete loop throughout the entire engineering spaces. Figure 52 shows the general arrangement of this system for the DD445 class. Details of arrangement differ slightly in the DD692 class from that shown but not sufficiently to warrant an additional drawing. Auxiliary steam is led directly from the boiler steam drums without the use of a desuperheater since the superheater in this boiler is separately fired. The auxiliary steam boiler stop valves are backed up by guarding valves. The guarding valves can be opened only from the fireroom. The auxiliary stop valve can be opened from the deck as well as the fireroom. This arrangement allows the boiler to be cut off the line from the deck but does not allow it to be put on the line unless the guarding valve is opened in the fireroom. This insures that the fireroom watch knows when the boiler is put on the line. Each boiler leads to both sides of the auxiliary steam loop, but they are so arranged that with the boiler stops open Nos. 1 and 3 boilers cannot be cut off the starboard side of the loop and Nos. 2 and 4 boilers cannot be cut off the port side. On the port side of No. 1 fireroom, arranged as shown in figure 52, are the branches to the fireroom auxiliaries on the lower level. The line stop valves here are so arranged that all these branches may be cut in from either direction or so that either half may be used alone. The branches are so arranged that one fuel oil service lump is serviced from each side of the center cutout valve and the emergency feed pump may be furnished with steam from either side. The fire and bilge and the fuel-oil booster pumps are not considered sufficiently important to have parallel leads. In the fireroom, on the port side of the forward loop, is provided in the engine room which is also a remote operated valve. The auxiliary steam line leads from both of these valves aft through the engine room and looping across joins together at the valve shown in the center of the engine room. This completes the forward auxiliary steam loop. Branches are led from both sides of this cut-out valve to the main and auxiliary air ejectors and, where two steam lubricating oil pumps are installed, to both lube oil pumps. One main feed pump is served from one side of this valve and the other is served from the opposite side. The other steam pumps on the lower level are served by a line from the starboard side of the cut-out valve. If there is no steam on the starboard side of the loop, this means that the electric condensate pump and the electric main feed booster pump must be operated. In effect the arrangement in the after plant is exactly the same. The three valves, seen in the starboard lead from No. 4 boiler, correspond exactly to the three valves shown on the port side of the loop in No. 1 fireroom. The starboard line cut-out valve is in the fireroom and the port line cut-out valve is in the engine room. The cut-out valve, shown on the starboard side, divides the loop in No. 2 engine room and branches to the air ejectors, and the main feed pumps lead off as shown in the same manner as those discussed in connection with the forward loop. Two cross-connection valves will be noted at the after bulkhead of the No. 1 engine room. They allow the two separate loops to be joined together to form a single loop through the entire plant for parallel operation. Under normal operation the plants should be divided and both of these cross-connection valves closed. Then steam should normally be led to No. 1 engine room down the port side of the forward loop, and to No. 2 engine room down the starboard side of the after loop. This would allow the bulkhead stop valves in both engine rooms to be closed. Minor branches, other than those shown, lead from this system in the fireroom to the 165 p.s.i. steam system and to the steam smothering system.

located a cut-out valve which can be operated either from the deck or from the fireroom. On the starboard side a cut-out valve is

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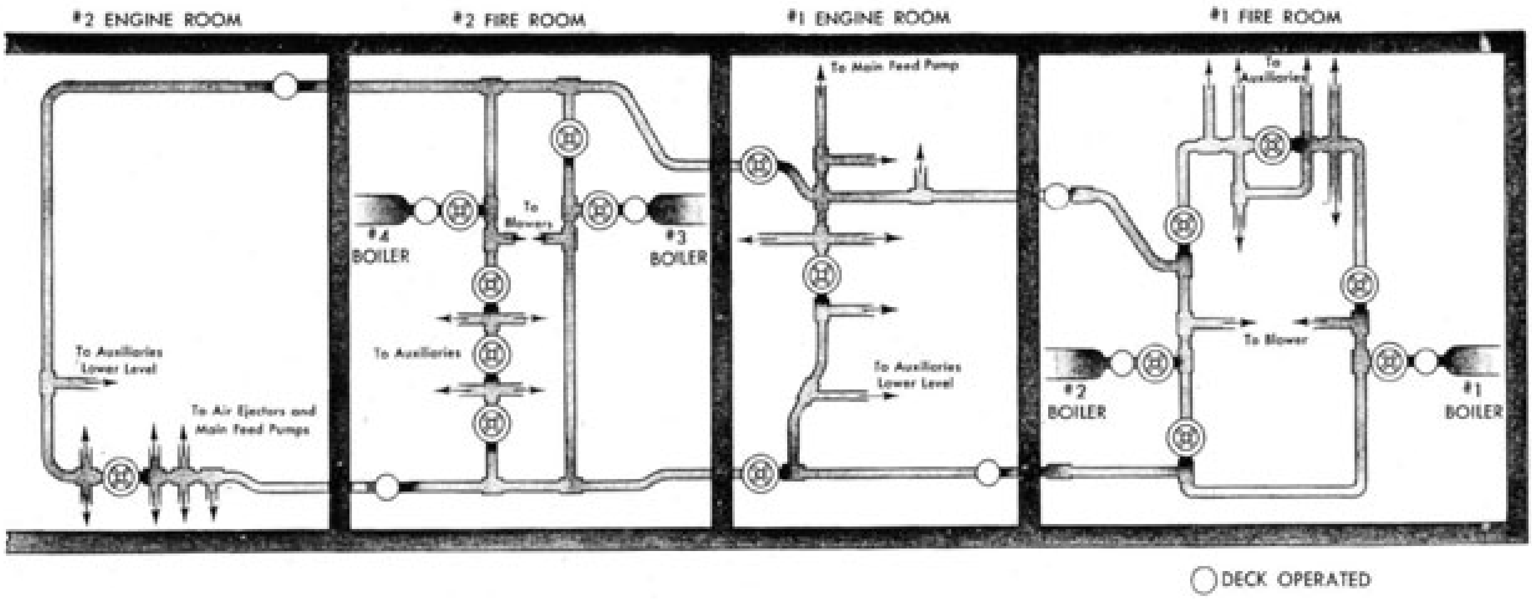

AUXILIARY STEAM SYSTEM
FIG. 52

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(b) DD692 Class Auxiliary Steam.-The auxiliary steam system in the DD692 class is essentially the same as described above. However, the bulkhead stop valves in each plant are both in the fireroom, and the cross-connection valves are located with the starboard one in No. 1 engine room and the port one in No. 2 fireroom. Branches from both sides of each engine room cut-out (or crossover valve, are led to the lower level so that the steam pumps there can be served from either side of the loop.

(c) Grove Air Operated Pressure Reducing Valve.- To provide steam under reduced pressure for various services, steam is led from the auxiliary steam line through Grove air-operated reducing valves. The following Grove valves are installed in the ship:

(1) *Steam to main and auxiliary air ejectors.*- Two

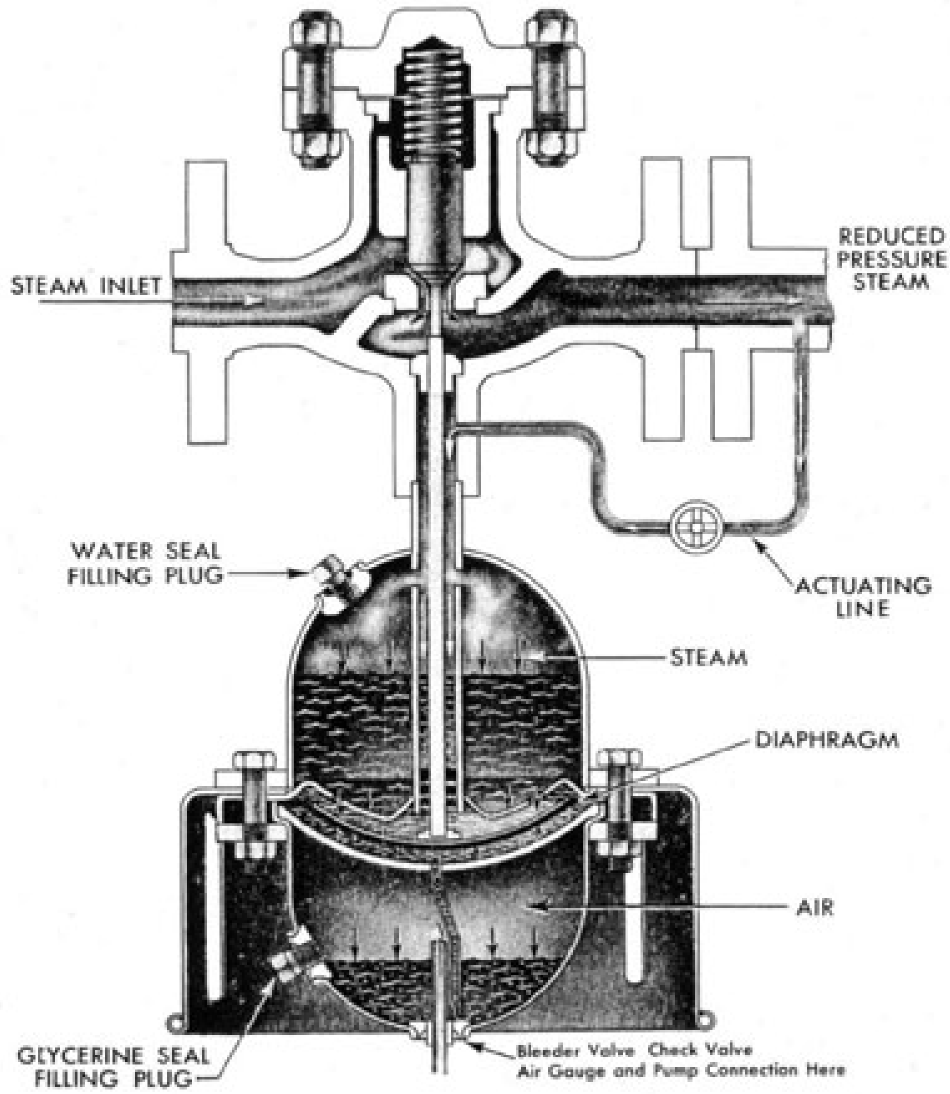
through a valve back to the upper part of the dome in the manner shown in the drawing. Steam at the reduced pressure will then exert a force on the top of the water seal. This force will be transmitted through the water to the top of the diaphragm. When this pressure exceeds the pressure of air in the lower half of the dome, working against the bottom of the diaphragm, the diaphragm will be displaced downward causing the valve to close off. When the reduced steam pressure delivered from the valve then is equal to the air pressure pumped into the bottom half of the dome, the valve should take a stationary position which will pass sufficient steam to maintain that pressure. If the load increases, tending to take more steam away from the valve, the steam pressure will be momentarily reduced. This causes the air pressure to become greater than the steam pressure working down on top of the diaphragm and allow the valve to be opened wider to restore the pressure to normal. If the load is

in each engine room; 600/275 p.s.i.

(2) *Steam to 165 p.s.i.* (*or 150 p. 8. i.*) *line.*- Two in each fireroom; 600/165 p.s.i. (or 150 p.s.i.) auxiliary steam line.

(3) *Steam to heating and constant service.*- Two in No. 1 fireroom and two in No. 2 engineroom; 165 (or 150) /40 p.s.i. (4) *Steam to laundry.*-One in No. 1 engineroom; 165 (or 150)/100 p.s.i. -

Figure 53 illustrates construction and manner of operation of this valve. A neoprene rubber diaphragm is installed in the center of the dome. The bottom of this diaphragm is separated from the bottom half of the dome by a fixed steel plate. The top of the diaphragm is connected through holes in the shrouding, as shown, to the upper part of the dome. In the lower half of the dome a seal of glycerine is carried, and the upper half of the dome carries a level of water for sealing. A pipe connection is led from the protection plate below the diaphragm to a point which is below the level of the glycerine seal. When air pressure is pumped in, through the air connection, it will exert a pressure downward against the glycerine seal thus forcing glycerine up through this pipe connection into the space between the lower protection plate and the diaphragm. This same pressure will exert a force upward against the diaphragm thus causing the diaphragm to be displaced upward. Since the valve stem of the valve is in contact with this diaphragm, moving the diaphragm upward will cause valve to be forced open and allow steam to pass through the valve seat into the outlet connection. From the outlet connection an actuating line is led reduced this will cause a momentary increase in steam pressure thereby increasing the pressure on top of the diaphragm above that of the air pressure below it and cause the diaphragm to be displaced downward, reducing steam flow through the valve to again restore the delivered pressure to normal. Thus, theoretically, the valve should deliver a pressure of steam equal to the pressure of air pumped into the lower half of the dome. Since the valve itself has weight and a light spring tending to close it, it is necessary to introduce slightly more air pressure than it is expected to have steam pressure delivered. In general for the higher pressure valves, about 10 p. s.i. additional air pressure is required. If air is pumped into the valve when it is cold it is necessary to pump in slightly less air pressure, since warming up the valve will cause the air pressure to increase slightly. The shroud shown, extending outside the dome from the center flange, appears only on the high pressure valves. This is of copper and is installed to allow for the transmission of heat from the upper half of the dome to the atmosphere and prevent that heat from passing into the lower half. where it may cause an excessive rise in pressure of the air. Each of these valves is set between inlet and outlet cut-out valves. In order to put the Grove valve in operation the discharge valve should first be opened. Then if proper pressure of air is in the dome, the inlet valve should be opened slowly. allowing the valve to heat up. The valve in the actuating line must he open. It will he difficult



GROVE REDUCING VALVE
FIG. 53

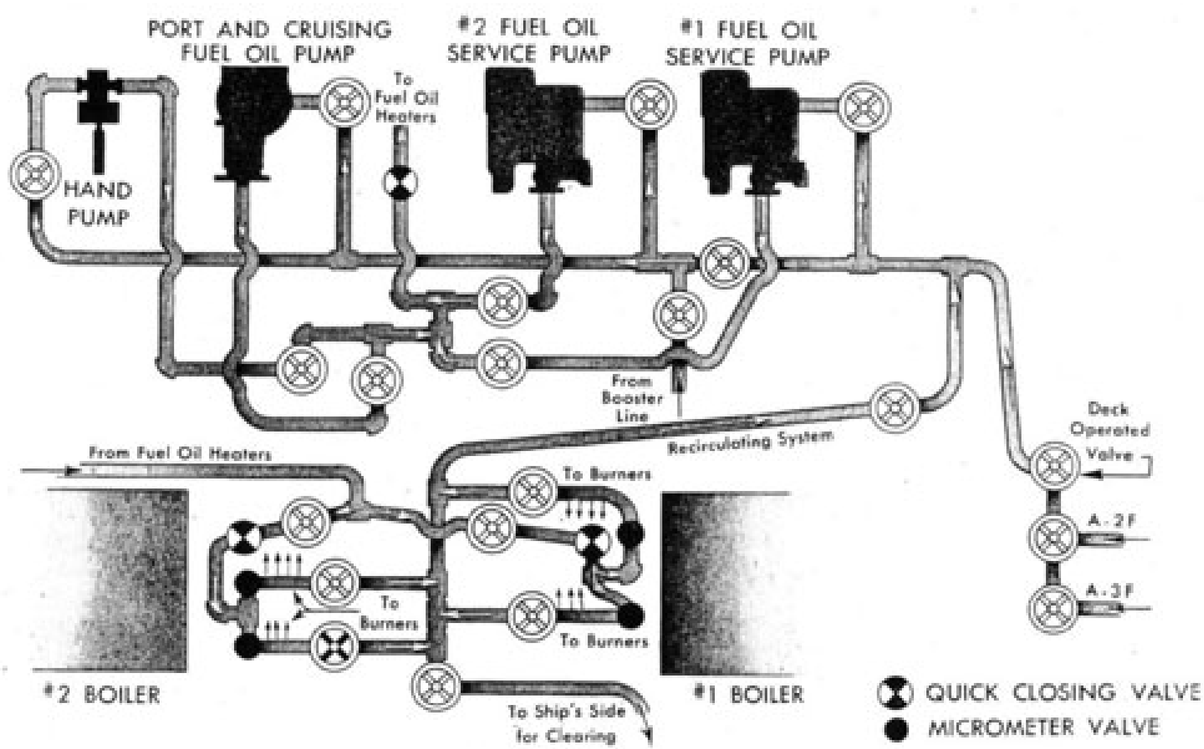
to get these valves on the line unless some steam is being bled away from the discharge, so it is desirable if possible to have some steam leaving the valve when cutting in. If care is taken to properly warm up these valves and lo put them on the line slowly, no trouble should be encountered with their operation. The lower seal should always be of glycerine. The upper seal is of water, and condensation of the steam in the upper part of the dome should be sufficient so that it will never require refilling.

2. FUEL OIL SYSTEMS

(a) Fuel Oil Service Systems.-For each plant there are two fuel oil tanks designated as fuel oil service tanks, from which the oil furnished to the fuel oil burners is pumped. These two tanks are the after center line tanks of the forward group. i.e.. A2F and A3F, and the forward center line tanks of the after group i. e., C1F and C4F. Oil is pumped through the fuel oil service pumps and discharged through the fuel oil heaters and strainer to the boilers. The construction of the

fuel oil service pump is similar to that of the lubricating oil service pump, except that the pump is of smaller capacity and is designed to deliver a maximum operating pressure of 350 p.s.i. The turbine end and the governor are the same as those on the lubricating oil pumps, with the governor setting being 1,141 r.p.m. Governor travel is the same as on the lubricating oil pumps, namely three-eighth inch. All fuel oil service pumps are steam-driven. There are two fuel oil service pumps installed in each fireroom, each taking suction from its own group of service tanks through a suction line common with the other pump in the same space. In addition to these pumps, on early ships of the DD445 class, a port and cruising fuel oil pump is also installed for port use. It is probable that port-use fuel oil service pumps will be installed in the remaining ships of the DD445 class and in all ships of the DD692 class as a post-war project. This pump is a vertical variable stroke pump built on the principle of the *A* end of a Waterbury speed gear, and has a maximum capacity of 10 gallons per minute at 350 p.s.i. The main fuel oil pumps are controlled by Leslie constant pressure pump governors, the construction of which is exactly similar to the one previously described in the discussion of the lubricating oil pumps. The diaphragms and springs are designed to take care of the higher discharge pressure of the pump but the operation and adjustments of the governor are the same. There is one fuel oil heater in each fireroom consisting of four units, which can be operated either singly or with any number of units in parallel. Steam for this heater comes from the auxiliary steam line, and the drain passes through a combined inspection tank and trap, to insure condensation of all steam admitted to the heater (thus obtaining maximum heat transfer efficiency) and to note fuel oil contamination of the drains. A meter is fitted in the line before the heater, and after the heater the oil passes through a double-barrelled strainer, before going to the boiler fronts. The fuel oil service suction manifold is located on the forward bulkhead of the forward fireroom. It consists of three valves, the left-hand one of port-and-cruising fuel oil service pump. and the hand fuel oil service pump. A line leads from the fuel oil booster system into the suction line between the two fuel oil service pumps. This allows the booster pump to put a pressure on the suctions of the service pumps if necessary. Each pump is provided with its own suction valve at the pump. Between the port-and-cruising pump and No. 2 fuel oil service pump is the discharge manifold which carries the discharge valves from all four pumps. They are arranged as shown in the sketch, and discharge overhead through a quick-closing valve to the heaters. This quick-closing valve, directly after the pump discharge manifold, is rigged with a wire pull so that it can be closed from the deck and cut off oil from the boilers in case of emergency. The discharge line leads to the heater, with a bypass around each element, and beyond the heater joins into a single line again to go through the strainer. From there it leads between the boilers and branches off to two cut-out valves, each of which leads to one boiler. Each line passes through another quick closing valve before going to the burner manifolds. This valve is rigged to be operated by a wire pull from the upper grating between the boilers, so that in case of low water or other casualty it can be closed by the check man to cut off oil from the boiler. After passing through this valve each line branches to both the saturated and superheater burner manifolds. A micrometer valve is installed in the line before each manifold by means of which the oil pressure to the burners themselves may be adjusted. This is necessary in order that the fuel oil service pump may carry a constant pressure and yet deliver different pressures to the two manifolds, as is most frequently the case. In order to allow oil to pass through the heater to heat up the oil to proper temperature before lighting off, recirculating valves are provided at the base of each burner manifold. These valves will lead oil directly from the manifold back to the suction line of the fuel oil service pumps. It should be noted in this connection that the oil should never be heated above the temperature corresponding to 150 S. S. U. or excessive wear on the pump rotors and barrel will occur due to inadequate lubrication. From this recirculating

which is a cut-out valve for the entire manifold. The center valve is for suction from tank A2F and the right-hand one for suction from tank A3F. The suction line leads from this manifold down the port side and through a cut-out valve. After this cut-out valve, branches lead off (fig. 54) to both fuel oil service pumps, the system is also led a line to the ships side to allow oil to be pumped overboard from the system in case water has gotten into the system. This "clearing" line is furnished in order to clear this water out before taking



FUEL OIL SERVICE SYSTEM - #1 FIRE ROOM
FIG. 54

suction on another tank, and to prevent pumping it into the boiler furnace. The sketch of the after system shows it to be exactly similar to the forward system in general arrangement. However, the service suction manifold is in the engineroom in this case. The tanks used are the centerline tanks in the after group, C1F and C4F. The recirculating line, instead of joining the suction line between the tanks and the line cut-out, enters after the line cut-out, and the booster connection to the service suction line enters between No. 3 service pump and the port-and-cruising service pump. Otherwise the system is the same, including the recirculating system and clearing line. Where no port-and-cruising pump is installed DD692 class (long hulls) ships have three tanks located between the forward engineroom and the after fireroom. A connection from the manifold to the transfer system in the forward engineroom has been provided to permit using the center line tank, B-9 1/4 F, as an emergency fuel oil service tank.

The Bureau recommends the following fuel oil service tank procedure:

(1) Take suction from one service tank of each system at a time.

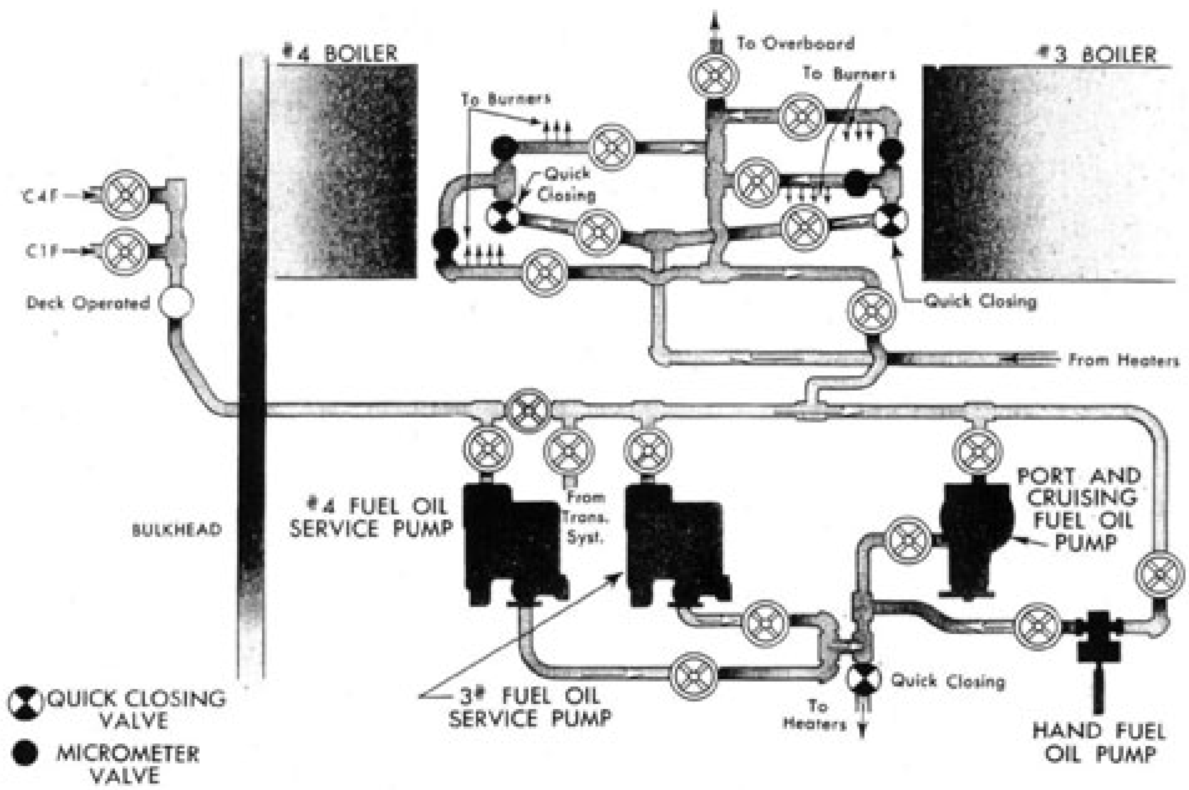
(2) Maintain the fuel oil service tank levels between

the foundation and fittings have been retained to provide for future installation, when production will permit. With the exception of the service tank numbers, the fuel oil service system of the DD692 class is the same as for the DD445 class. The forward tanks on the DD692 class are A3F and A4F and the after tanks are C1F and C6F.

95 and 50 per cent, to insure an adequate gravity head.

(3) Fill the stand-by service tank of each system shortly after shifting suction to the adjacent service tank, for settling-out water and sediment.

(4) Prior to taking suction from a stand-by service tank take a thief-sample if practicable; and take a low suction for a short interval and



FUEL OIL SERVICE SYSTEM - AFTER GROUP FIG. 55

discharge to the contaminated oil tank or overboard, as operating conditions permit.

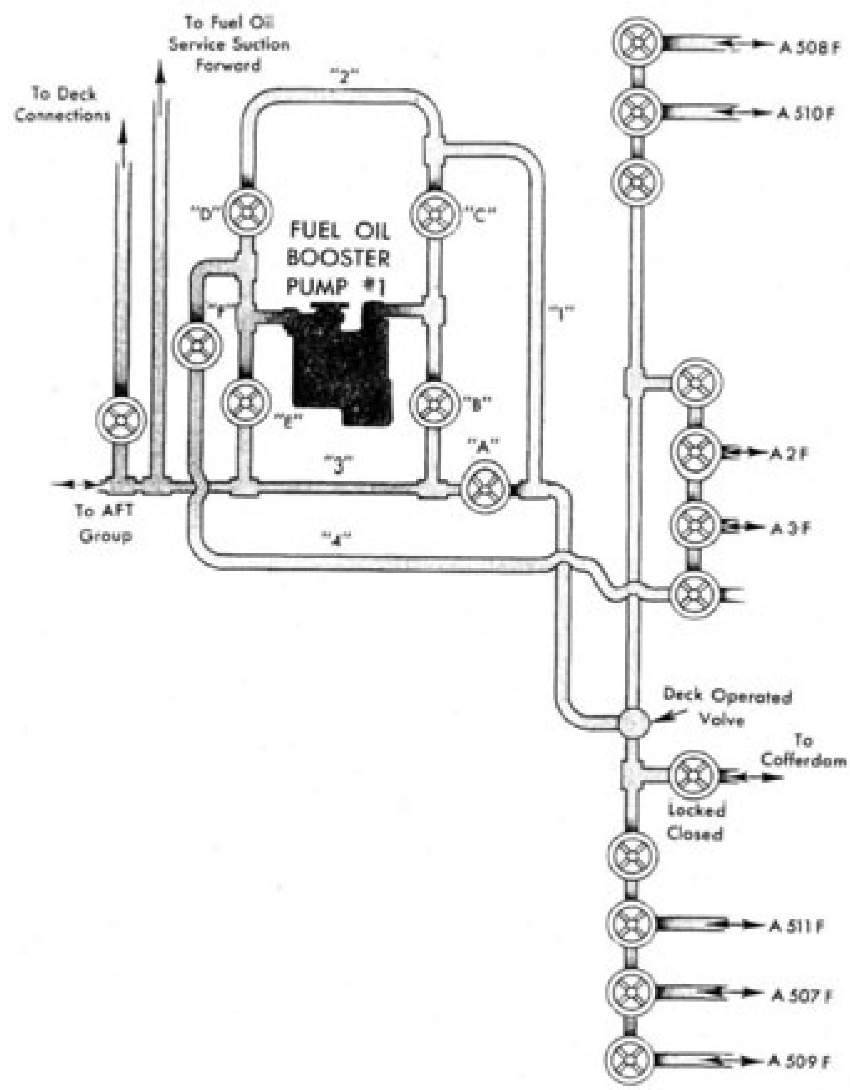
Satisfactory thief samplers can be manufactured aboard ship. The Bureau's latest plan of one suitable for sounding-tube use is BuShips Plan S5501-64052-SK of 16 August 1943 (Sounding Tube Oil Samplers). The oil samples can be inspected visually in a glass bottle, or centrifuged if a centrifuge is available.

(b) The Fuel Oil Transfer System DD445 Class.-

to the forward fuel oil tanks, as shown in figure 56, by three manifolds located on the forward bulkhead of the forward fireroom. The center manifold is for the fuel oil service tanks A2F and A3F. This is a four-valve manifold, the end valves on the manifold being cut-out valves for the manifold. The left-hand space valve is the cut-out for suction from the tanks and the right-hand valve is the cut-out valve for discharge to the tanks. The manifold on the port side is a three-valve manifold and connects to the port wing tanks A508F and A510F. The right-hand valve is the manifold cut-out valve. The manifold on the

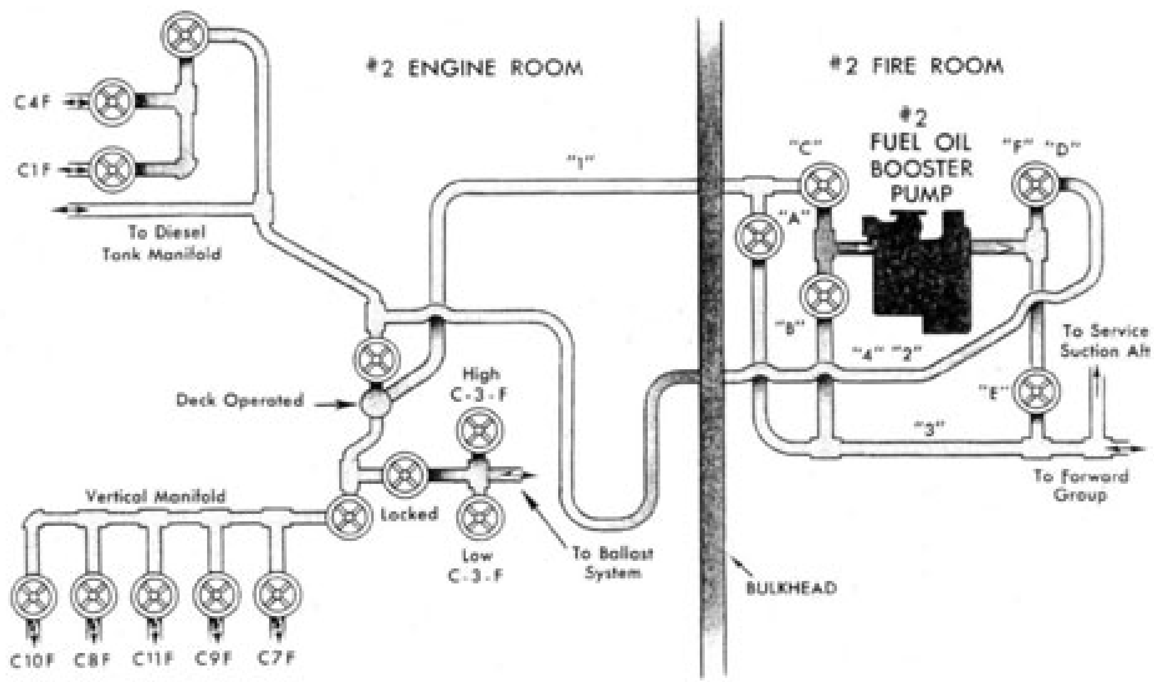
The only pump involved in the transfer system is the fuel oil booster and transfer pump. This pump is constructed in the same manner as the fuel oil service pump, except that it is designed to operate at a lower pressure with a higher capacity than the service pump. The pump is rated to discharge 100 gallons per minute at a pressure of 100 p.s.i. Under normal operation (transferring oil) the discharge pressure will not be this high due to the lack of a head to pump against, and the capacity will be controlled by the speed of the pump. The booster pump is connected

starboard side is a four-valve manifold and connects to tanks A511F, A507F and A509F, in that order. The left-hand valve of this manifold is the manifold cut-out valve. These manifolds are all joined together by a common line as shown and lead to the No. 1 fuel oil booster pump through a cut-out valve which may be operated either from the fireroom or from the deck. In addition, a single valve branches from the



FUEL OIL TRANSFER SYSTEM
FORWARD GROUP 445 CLASS
FIG. 56

common line and connects to the cofferdam. This valve is locked closed. The line leading to the fuel oil booster pump passes through another cutout valve and then leads on past the booster pump to cross-connect with the after transfer system. The suction manifold of the booster pump consists of two valves which have been lettered *B* and *C* for convenience in explanation. The additional cutout valve shown has been lettered *A*. The discharge manifold of the pump consists of three valves which have been lettered *D*, *E*, and *F*. Valves *B* and *E* are connected to the cross-connection line as shown. Valve *F* is connected to the discharge cut-out valve of the service tank manifold. Line *1* leads as shown to the discharge side of valve *C* and into line 2 which joins valves *D*, and *C*. To take a suction from any tank of the forward group and discharge into the fuel oil service tanks, valve *A* is closed and suction drawn through line *1* and valve *C*. Discharge is led through valve F to the service tank manifold. The service tanks are the only ones in the forward group into which oil can be discharged when taking suction from tanks in the forward group. To take suction from the forward tanks and discharge aft, suction is taken through valve *C* and the oil discharged through valve *E*. To take suction from the after group and discharge forward



FUEL OIL TRANSFER SYSTEM
AFT GROUP - 445 CLASS
FIG. 57

the oil passes through line *3* and valve *B*, discharging through valve *D* and lines *2* and *1* to the tank manifold required with valve *A* remaining closed. From the crossconnection line a branch is led into the fuel oil service pump suction line, by means of which oil can be pumped into the crossconnection and then into the service pump suction when necessary. For the after pump to take suction from or discharge into the forward tanks the crossconnection can be opened by opening valve *A*. The only time valve A should have to be open is when taking suction from or discharging into the forward tanks with the after booster pump. The manifolds for the after group of tanks are located on the after bulkhead of No. 2 engineroom. The manifold for the service tanks is a three-valve manifold, the right-hand valve of which is the manifold cut-out valve. There is a single six-valve manifold for the other five tanks in the after group, the lower one of which is the manifold cut-out valve. The after service tanks are C1F and C4F and the storage tanks aft are C10F. C8F, C11F, C9F, and C7F. These two manifolds are joined as shown by a line containing two cut-out valves one of which can be operated from the deck as well as from the engine room. The deck operated cut-out valve is connected to the suction manifold of the after booster pump in No. 2 fireroom. Branching from the manifold line as shown in the contaminated oil tank (C3F) manifold which has two valves, one for high suction and one for low suction. A cut-out valve to this manifold from the transfer system is provided which should he kept locked unless in use. The suction manifold of the booster pump consists of two valves marked *B* and *C*. and the discharge manifold also of two valves marked *E* and *FD*. Valve *A* is a bypass valve and serves the same purpose as valve *A* in the forward group. In order to take a suction from the after tanks and discharge into the after service tanks the oil is led from the storage tank manifold through the deck operated valve to the suction of the booster pump through valve *C*. It is discharged through valve *FD* and line 4 and 2 up to the service tank manifold with the cut-out valve in the manifold crossconnection line closed to prevent the discharge from going back into the suction. As in

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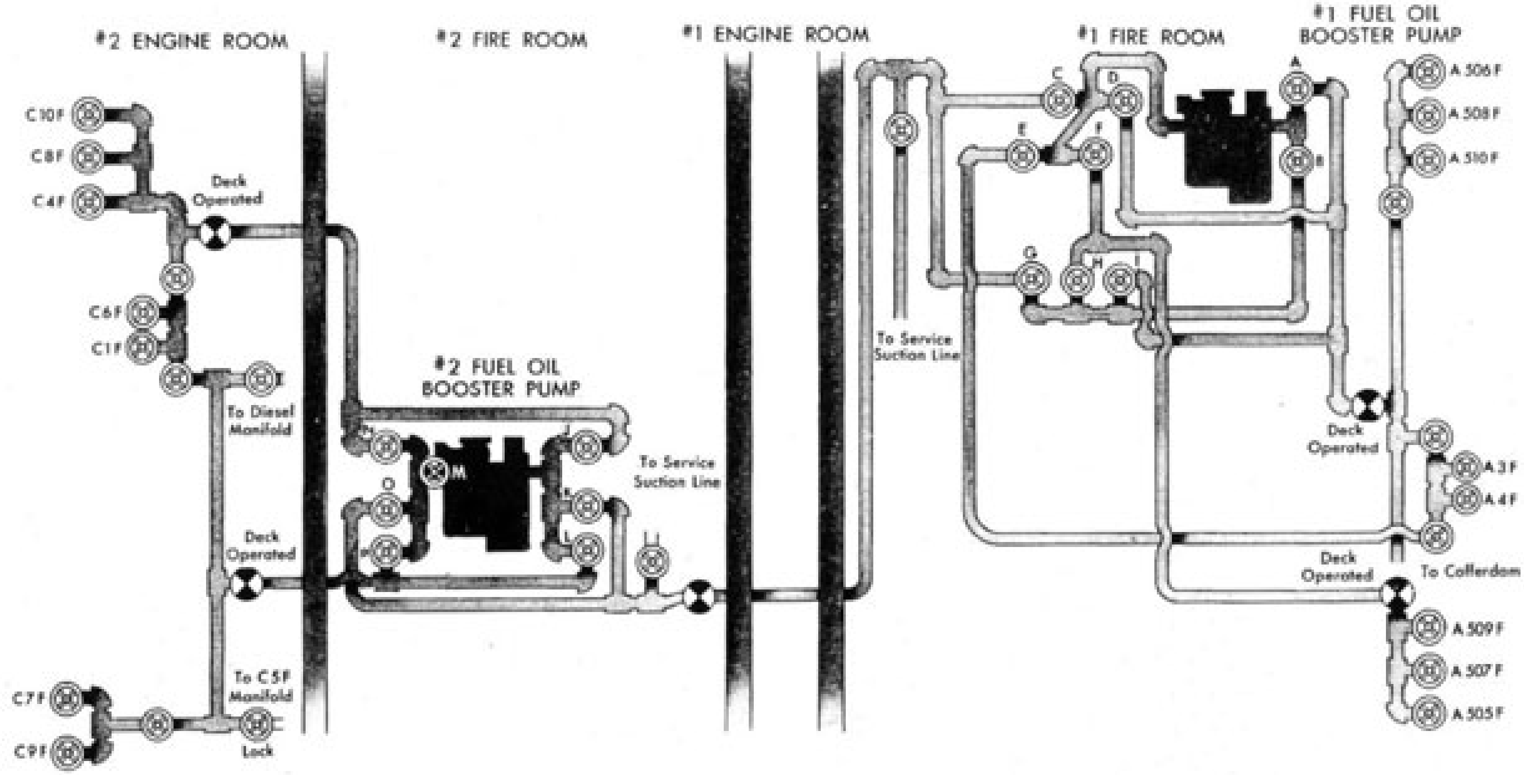
the forward system, a suction cannot be taken from the after tanks and discharge into any tanks aft except the service tanks. To take a suction from aft and discharge to the forward system through the crossconnection line the suction is drawn through line 1 and valve *C* and discharged through valve *E* to the crossconnection line. To take a suction from the forward group and discharge to the after group the suction is led through line 3 and valve *B* and discharged through valve *FD* to the manifold crossconnection. When using the forward booster pump on the after system, either taking suction or discharging, the bypass valve *A* will bypass the after pump and connect the forward pump directly with the tanks. Thus valve *A* need only be used when using the forward pump on the after system. From the manifold crossconnection in this after system a branch is led off to crossconnect the diesel oil tank service tank manifold. which allows for the transfer of oil from any storage tank to the fuel oil service tanks. In order to use No. 1 fuel oil booster pump for transfer of oil from the forward group of tanks to the after group, the discharge can be led through valve *C* of the pump discharge manifold. This will put pressure on the cross-connection line, and in order to lead oil to the after tanks, valve *O* in the after fireroom must be open and the valves *N* or *P*, depending on which tanks are to be used. To take suction with No. 1 fuel oil booster pump from the after tanks, it is necessary to open valves *G* and *B*. This will open the cross-connection line to the suction of the forward pump, and opening the same valves previously mentioned in the after fireroom will connect the cross-connection line with whichever tank in the after group is desired. The discharge in this case can be led to the forward tanks either through valves *B* or *F*. In the after fireroom

manifold with this system.

(c) Fuel Oil Transfer System-DD692 Class. The arrangement of the fuel oil transfer system differs considerably from that of the DD445 class. Figure 58 is a schematic representation of this system. It will be noted that the manifolds connecting to the forward fuel oil tanks are not all connected to a single line as in the DD445 class. The manifold for the starboard tanks is entirely separate from those of the fuel oil service tanks and the port storage tanks. The suction manifold of No. 1 fuel oil booster pump consists of the valves lettered *A* and *B*. The discharge manifold of this same pump consists of the valves lettered *C*, *D*, *K* and *F*. Valves *G*, *H*, and *I* can be termed the Cross-Connection Manifold. This system is arranged so that in addition to being able to transfer oil from the forward group of fuel oil tanks to the after group of fuel oil tanks or vice versa, and from any fuel oil tank to the fuel oil service tanks, it is possible to transfer oil from one side of the ship to the other in the same group. To take suction from the port group of tanks forward and from the fuel oil service tanks it is necessary to use valve *A* of the suction manifold. Taking suction from here, oil may be transferred either to the after system through valve *C*, or to the starboard tanks forward through valve *F*. To transfer oil from the starboard tanks forward to the port side it is necessary to take suction through valves *H* and *B* and discharge through valve *B* of the discharge manifold. A separate line is provided leading from the discharge manifold and its valve *E*, directly to the valves *J*, *K*, and *L* comprise the suction manifold, and *M*, *N*, *O*, and *P*, the discharge manifold. Valve *M* is a pump discharge cut-out valve. It is installed in this pump to prevent pressure from the cross-connection line from backing into the pump from the discharge manifold. If this were allowed to occur when No. 2 pump is not in operation the pump would operate backward. This valve *M* should never be open unless No. 2 pump is in operation. The after manifolds are arranged to allow transfer of oil from one side to the other and to the fuel oil service tanks, as in the forward system. To take suction from the port side valve *L* is used, and to discharge to the starboard side valve *P* should be opened. To take suction from the starboard side valve *L* is opened and the discharge to the port side is led through valve *N*. To discharge to the after service manifold from any tank a separate line is not provided. However, by closing the proper service tank manifold cut-out valve oil can be discharged to the service tanks from either side of the ship. Inspection of the after manifold arrangement will make this apparent. If the after pump is used to take suction from the forward system, valve *K* must be opened and in the cross-connection manifold in the forward fireroom valve *G* should be opened. This opens the cross-connection manifold and valve *H* or *I* will allow suction from the forward tanks. To discharge from the after pump into the forward system, valve *O* must be opened and valve *G* in the cross-connection manifold will allow distribution



FUEL OIL TRANSFER SYSTEM
692 CLASS (SHORT HULL)
FIG. 58

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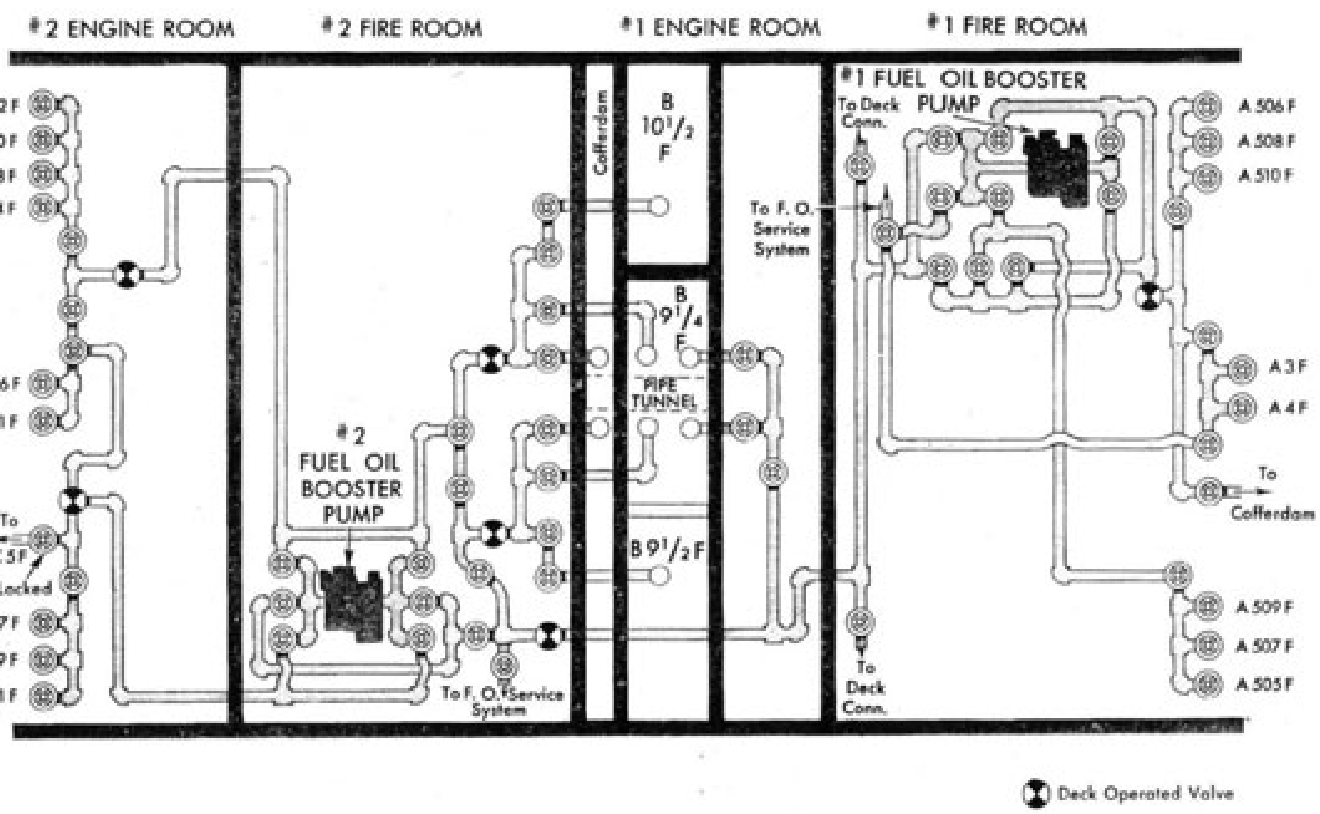
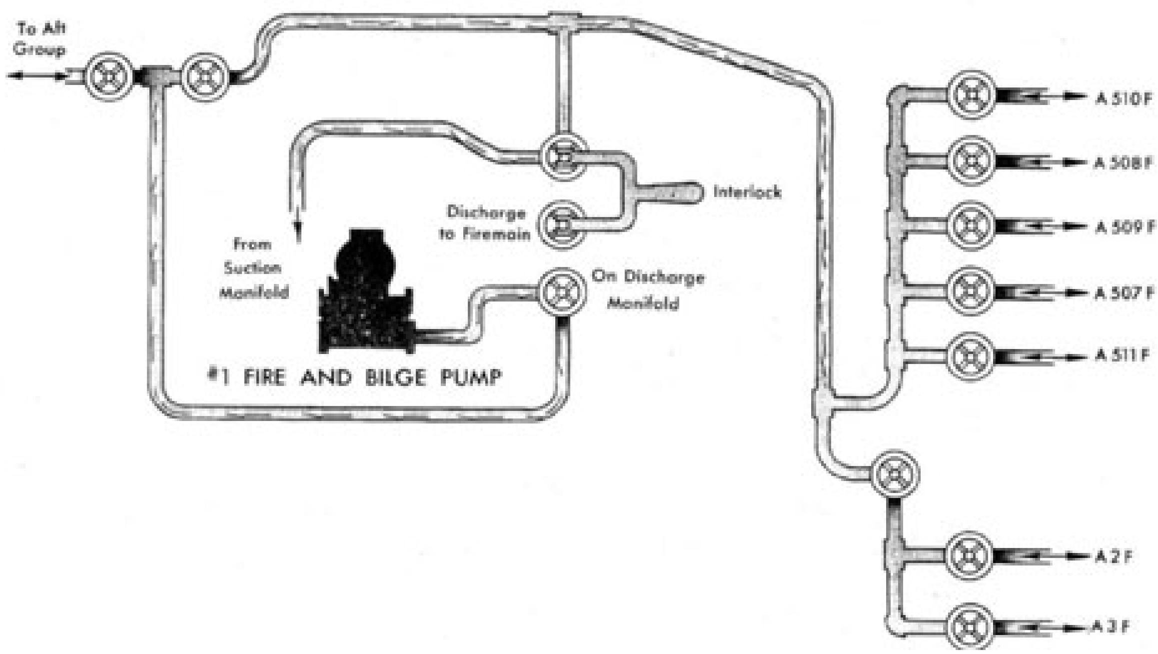


FUEL OIL TRANSFER SYSTEM
DD 692 CLASS (LONG HULL)
FIG. 58A



FUEL OIL TANK DRAIN SYSTEM
FORWARD GROUP - 445 CLASS
Fig. 59

through valve *H* or *I* to the forward tanks. Branches from the cross-connection line to the actually installed in the forward fireroom, is a service suction system appear in each fireroom as in the DD445 class. Not shown on figure 58 but riser from the cross-connection line which leads to the two deck connections. Deck operated valves, and the connections to the diesel tank manifold, the contaminated manifold and the cofferdam, appear as indicated.

The DD692 class (long hull) have three tanks located athwartships between the forward engine room and the after fire room. Manifolds located in the after fire room connect these tanks to the fuel oil transfer and fill empty fuel oil tanks with sea water and drain them of oil. To accomplish this, separate manifolds are provided which connect to the fuel oil tanks and to two of the fire and bilge pumps. The manifolds to the forward tanks connect to No. 1 fire and bilge pump and the manifolds to the after tanks connect to No. 4 fire and bilge pump. The ballast system forward has two manifolds located on the forward bulkhead of No. 1 fireroom. The six-valve manifold leads to all tanks forward except the service tanks, and has no cut-out valve on it. The manifold for the service tanks is separate, with a valve for each service tank and a cutout valve. Both manifolds lead into a common line which acts as a discharge as well as a suction line. This line leads to No. 1 fire and bilge pump suction manifold through a valve and also branches off as shown through a cut-out valve, to the crossconnection valve and to the fire and bilge pump discharge manifold. The crossconnection valve leads through the plant to the after system. The fire and bilge pump can take suction from the sea and discharge through the discharge valve and the cut-out valve into the manifold line to fill any tank.

drainage systems. A manifold located in the forward engine room and connected to the transfer system permits using the center line tank as an emergency service tank.

(d) The Fuel Oil Tank Drain and Ballast System DD 445 Class.-In order to completely drain any fuel oil tank as well as to maintain the ship in ballast and in a stable condition when fuel oil is expended from the tanks thus reducing the ship's displacement, it is necessary to provide a system to

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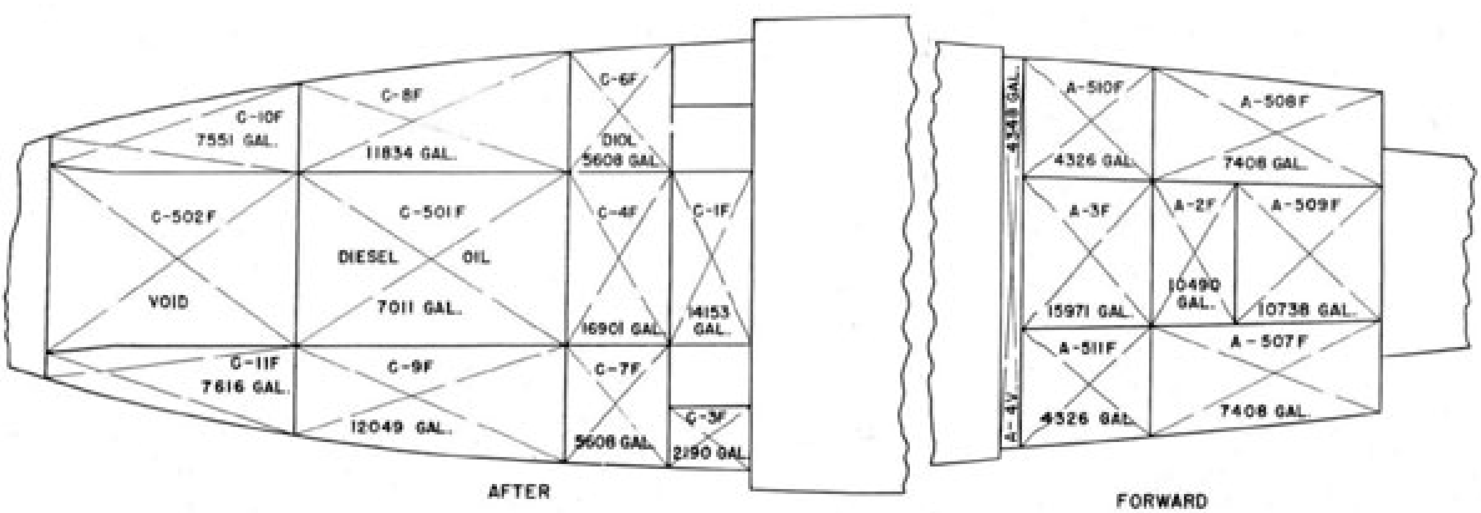
DD445 CLASS

Recommended sequence table for emptying fuel oil tanks

FORWARD GROUP				AFTER GROUP			
Time	Shift steaming suction to-	Take transfer suction from-	Transfer to-	Time	Shift steaming suction to-	Take transfer suction from-	Transfer to-
	A-2F				C-1F		
When A-2F is down 4,500 gallons.	A-3F	A-4V	A-2F	When C-1F is down 2,500 gallons.	C-4F	C-3F	C-1F
When A-3F is down 9,000 gallons.	A-2F	A-507F A-508F	A-3F	When C-4F is down 8,500	C-1F	C-10F C11-F	C-4F
When A-2F is down 6,000 gallons.	A-3F	A-507F A-508F	A-2F	When C-1F is down 7,000 gallons.	C-4F	C-10F C-11F	C-1F
BALLAST A-507F AND A-508A				BALLAST C-10F AND C-11F			

When A-SF is down 9,000 gallons.	A-2F	A-510F A-511F	A-3F	When C-4F is down 8,500 gallons.	C-1F	C-8F C-9F	C-4F
BALLAST A-510F AND A-511F							
When A-2F is down 5,000 gallons.	A-3F	A-509F	A-2F	When C-1F is down 7,000 gallons.	C-4F	C-8F C-9F	C1F
When A-3F is down 6,000 gallons.	A-2F	A-509F	A-3F	When C-4F is down 8,500 gallons.	C-1F	C-8F C-9F	C-4F
BALLAST A-509F				BALLAST C-8F AND C-9F			
When A-2F is down 4,000 gallons.	A-3F	C-7F	A-2F	When C-1F is down 1,600 gallons.	C-4F	C-7F	C-1F
BALLAST-C-7F							

NOTE-When it is known that the Diesel oil or Diol will have to he burned, mix these oils with at least an equal quantity of fuel oil. Extreme caution must, be exercised to prevent contamination of Diesel or Diol tanks with black oil when transferring these oils. Do not ballast C-501F or C-6F.



DD445 CLASS FUEL OIL TANK ARRANGEMENT

DD692 CLASS (SHORT HULL)

Recommended sequence table for emptying fuel oil tanks

FORWARD GROUP				AFTER GROUP			
Time	Shift steaming suction to-	Take transfer suction from-	Transfer to-	Time	Shift steaming suction to-	Take transfer suction from-	Transfer to-
	A-3F				C-1F		
When A-3F is down 6,000 gallons.	A-4F	A-5VF C-5F	A-3F	When C-1F is down 7,000 gallons.	C-6F	C-9F C-10F	C-1F
When A-4F is down 8,000 gallons.	A-3F	A-505F A-506F	A-4F	When C-6F is down 8,000 gallons.	C-1F	C-9F C-10F	C-6F
BALLAST A-505F AND A-506F							
When A-3F is down 9,500 gallons.	A-4F	A-507F A-508F	A-3F	When C-1F is down 7,000 gallons.	C-6F	C-9F C-10F	C-1F
BALLAST A-507F AND A-508F							
When A-4F is down 8,100 gallons.	A-3F	A-509F A-510F	A-4F	When C-6F is down 9,000 gallons.	C-1F	C-9F C-10F	C-6F
BALLAST A-509F AND A-510F				BALLAST C-9F AND C-10F			
When A-3F is down 8,000 gallons.	A-4F	C-7F C-8F	A-3F	When C-1F is down 6,000 gallons.	C-6F	C-7F C-8F	C-1F
BALLAST C-7F AND C-8F							
				When C-6F is down 3,000 gallons.	C-1F	C-4F	C-6SF
				BALLAST C-4F			

NOTE-When it is known that the Diesel oil or Diol will have to he burned, mix these oils with at least an equal quantity of fuel oil. Extreme caution must, be exercised to prevent contamination of Diesel or Diol tanks with black oil when transferring these oils. Do not ballast C-501F or C-502F.

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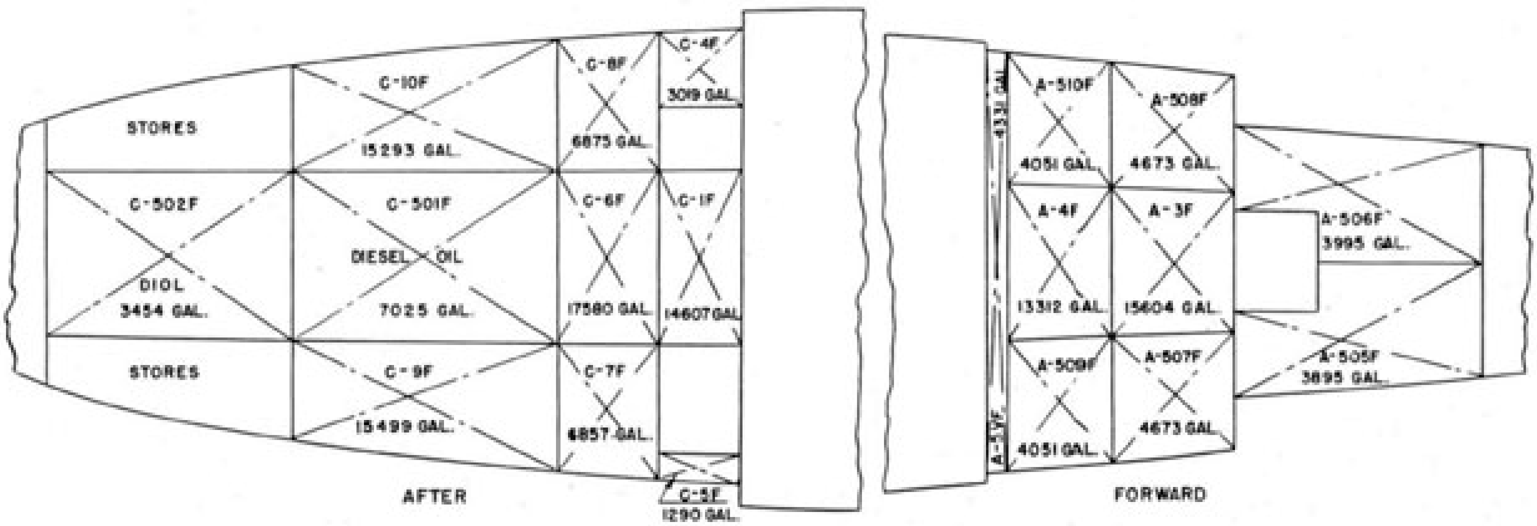

DD 692 CLASS (SHORT HULL)
FUEL OIL TANK ARRANGEMENT

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DD692 CLASS (LONG HULL) DESTROYERS

Recommended sequence table for emptying fuel oil tanks

FORWARD GROUP				AFTER GROUP			
Time	Shift steaming suction to-	Take transfer suction from-	Transfer to-	Time	Shift steaming suction to-	Take transfer suction from-	Transfer to-
	A-3F				C-1F		
When A-3F is down 6,000 gallons.	A-4F	A-5VF C-5F	A-3F	When C-1F is down 6,000 gallons.	C-6F	B-9 3/4VF	C-1F
When A-4F is down 8,000 gallons.	A-3F	A-505F A-506F	A-4F	When C-6F is down 8,000 gallons.	C-1F	C-11F C-12F	C-6F
BALLAST A-505F AND A-506F							

When A-3F is down 9,500 gallons.	A-4F	A-507F A-508F	A-3F	When C-1F is down 8,000 gallons.	C-6F	C-11F C-12F	C-1F
BALLAST A-507F AND A-506F							
When A-4F is down 8,100 gallons.	A-3F	A-509F A-510F	A-4F	When C-6F is down 5,500 gallons	C-1F	C-1IF C-12F	C-6F
BALLAST A-509F AND A-510F				DO NOT BALLAST C-11F AND C-12F			
When A-3F is down 7,500 gallons.	A-4F	C-9F C-10F	A-3F	When C-1F is down 8,000 gallons.	C-6F	C-9F C-10F	C-1F
When A-4F is down 7,500 gallons.	A-3F	C-9F C10F	A-4F	When C-6F is down 8,000 gallons.	C-1F	C-9F C-10F	C-6F
BALLAST C-9F AND C-10F							
When A-3F is down 7,000 gallons.	A-4F	C-7F C-8F	A-3F	When C-1F is down 7,000 gallons.	C-6F	C-7F C-8F	C-1F
BALLAST C-7F AND C-8F -							
				When C-6F is down 3,000 gallons.	C-1F	C-4F	C-6F
				BALLAST C-4F			
When A-4F is down 5,500 gallons.	A-3F	B-9 1/2F B-10 1/2F	A-4F	When C-1F is down 5,500 gallons.	C-6F	B-9 1/2F B-10 1/2F	C-1F
When A-3F is down 5,500 gallons.	A-4F	B-9 1/2F B-10 1/2F	A-3F	When C-6F is down 5,500 gallons.	C-1F	B-9 1/2F B-10 1/2F	C-6F
BALLAST B-9 1/2F AND B-10 1/2F							

When A-4F is down 8,500 gallons.	A-3F	B-9 1/4F	A-4F	When C-1F is down 8,500 gallons.	C-6F	B-9 1/4F	C-1F
DO NOT BALLAST B-9 1/4F							

NOTE-When it is known that the Diesel oil or Diol will have to he burned, mix these oils with at least an equal quantity of fuel oil. Extreme caution must, be exercised to prevent contamination of Diesel or Diol tanks with black oil when transferring these oils. Do not ballast C-501F or C-502F.

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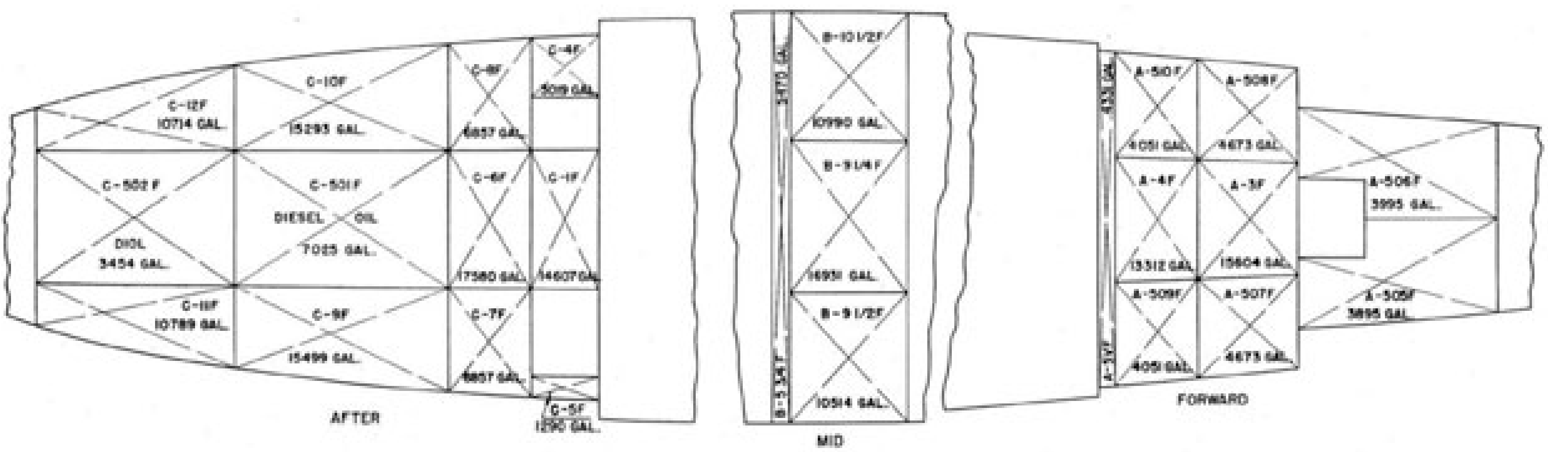

DD692 CLASS (LONG HULL)
FUEL OIL TANK ARRANGEMENT

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It can also take suction from any tank through the fire and bilge pump suction valve and discharge either overboard directly from the pump or into the after system through the cross-connection valve. From the after system the oil can be put into the contaminated tank to allow separation of the water from it. The manifolds are provided with sight drain valves by which it can be seen whether the discharge is clear water or contaminated. In the latter case it would be desirable to strip the tank into the contaminated tank. The entire after system is in the after engine room. The after system has two manifolds also, one for the service tanks with a cut-out valve, and one for the storage tanks without a cut-out valve. These join together and lead to one valve of a two-valve manifold. The other valve of this manifold leads to the contaminated tank manifold. From these two and these are the only fire and bilge pump on which the above interlocking yoke appears. The after system has a connection to the diesel fuel oil manifold, to provide for stripping or ballasting these tanks in the same manner as the fuel oil tanks.

(e) Fuel Oil Tank Drain and Ballast System (DD692 Class).-This system in the DD692 class has been revised from the initial installation which was similar to the DD445 class. The revised system permits pumping the forward group of tanks with Nos. 1 and 2 fire-and-bilge pumps (the midships tanks of long-hull ships being considered part of this group) and pumping the after group of tanks with Nos. 3 and 4 fire-and-bilge pumps. A cross-connection is provided between the forward and after systems.

valves a line leads to the fire and bilge pump suction valve. The discharge from the fire and bilge pump leads from its valve to a three-valve manifold. One valve of this manifold leads to the common line from the tank manifolds between the manifolds and the two-valve manifold previously mentioned. Another valve leads to the contaminated tank line as shown, and the third leads forward and joins the line from the forward system, making the cross-connection. Through this last manifold suction can be taken from the sea and discharged into any tank aft, into the contaminated tank or into the cross-connection to the forward system. We can also take suction from any after tank and discharge into the contaminated tank or tip to the forward system, or we can take suction from the contaminated tank and discharge into the tanks of either system. Note that while it is possible to discharge into either system with either pump this can only be done when taking suction from the other system. Also it is possible to take suction with a pump from the other system only when discharging directly overboard from the fire and bilge pump. The valve of the fire and bilge pump suction manifold, which connects to the ballast system. is so yoked to the pump discharge valve to the fire main that neither one can be opened unless the other is closed. This will prevent the pump from taking suction from the ballast system and discharging into the fire main. The only two pumps connected into the system in this manner are No. 1 fire and bilge pump in No. 1 fire room, and No. 4 fire and bilge pump in No. 2 engine room,

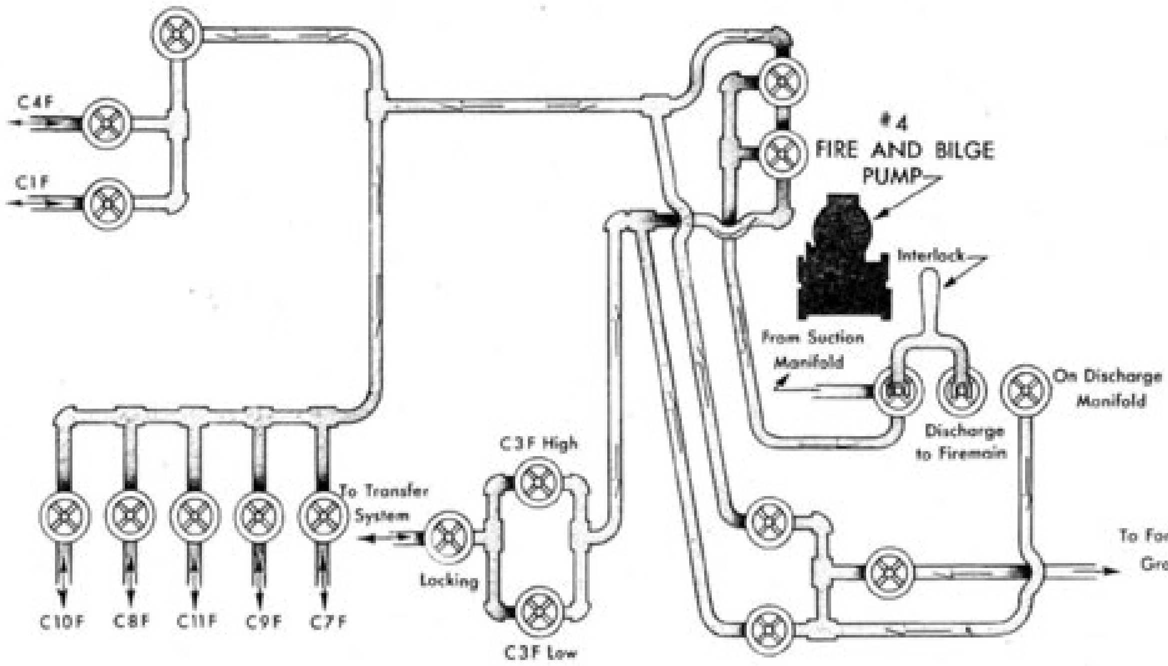
The drainage eductors are connected to the ballast system in their respective spaces to provide an alternate emergency unwatering facility in the event one or more of the fire-and-bilge pumps is inoperative or in use for another service. A swing-check valve is installed in the piping connecting the eductor to the main drain system to prevent contaminated water or fuel oil from entering this system.

The interlocks previously provided between the fuel oil tank drain suction valve and the fire-main discharge valve have been omitted in this revised arrangement. Warning tags have been provided in lieu thereof.

The diagrammatic arrangement of this system in the DD692 class (short hull and long hull) are shown in figures 61 and 61A, respectively.

3. THE AUXILIARY EXHAUST SYSTEM

(a) General Discussion.-This system consists of a continuous run of piping from the forward fireroom through the machinery spaces to the after engine room. The exhaust from all auxiliary steam equipment leads into this line. In each fireroom there is a spring-operated valve which can connect the auxiliary exhaust line to the atmosphere via the escape piping. In each engine room a branch leads up to the deaerating feed tank through a weight-loaded check valve to furnish steam for operation of the deaerating feed tank, Two Swartwout unloading valves are provided in each engine room, one discharging to the main con-denser and one to the auxiliary condenser. There are cut-out valves in the line at the forward and after bulkheads of the forward engine room and one at the forward bulkhead of the after engine



FUEL OIL TANK DRAIN SYSTEM
AFTER GROUP - 445 CLASS
FIG. 60

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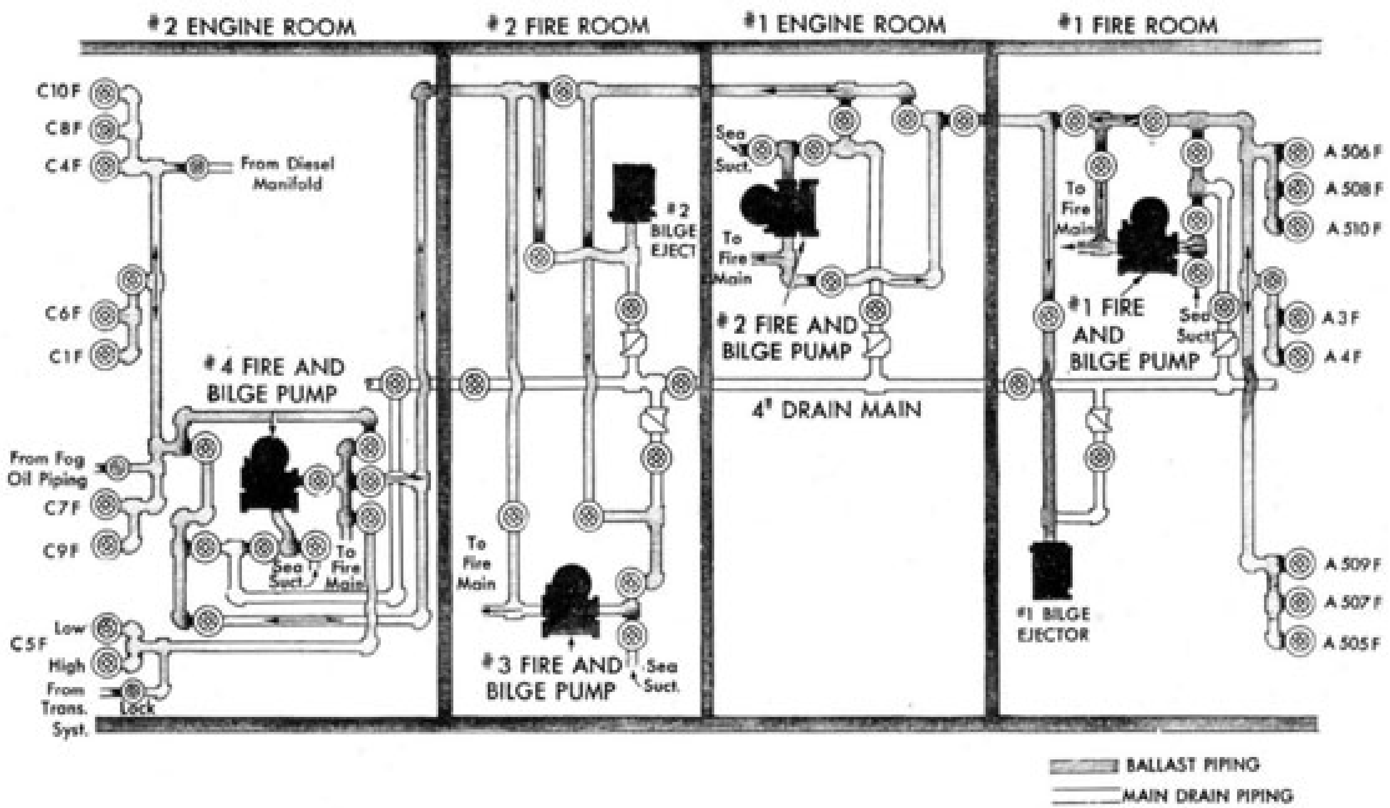

FUEL OIL TANK BALLAST SYSTEM
DD 692 CLASS (SHORT HULL)
FIG. 61

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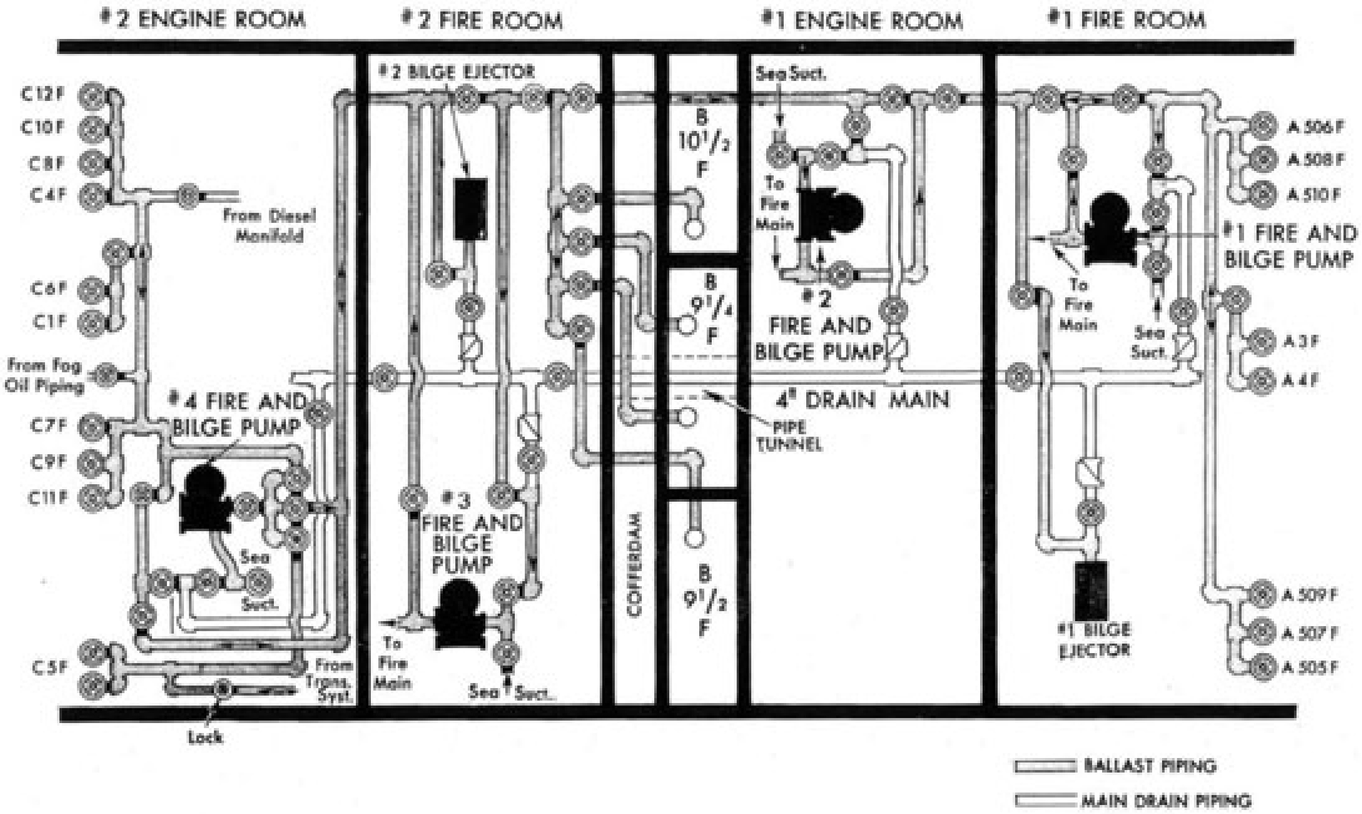

FUEL OIL TANK BALLAST SYSTEM
DD 692 CLASS (LONG HULL)
FIG. 61A

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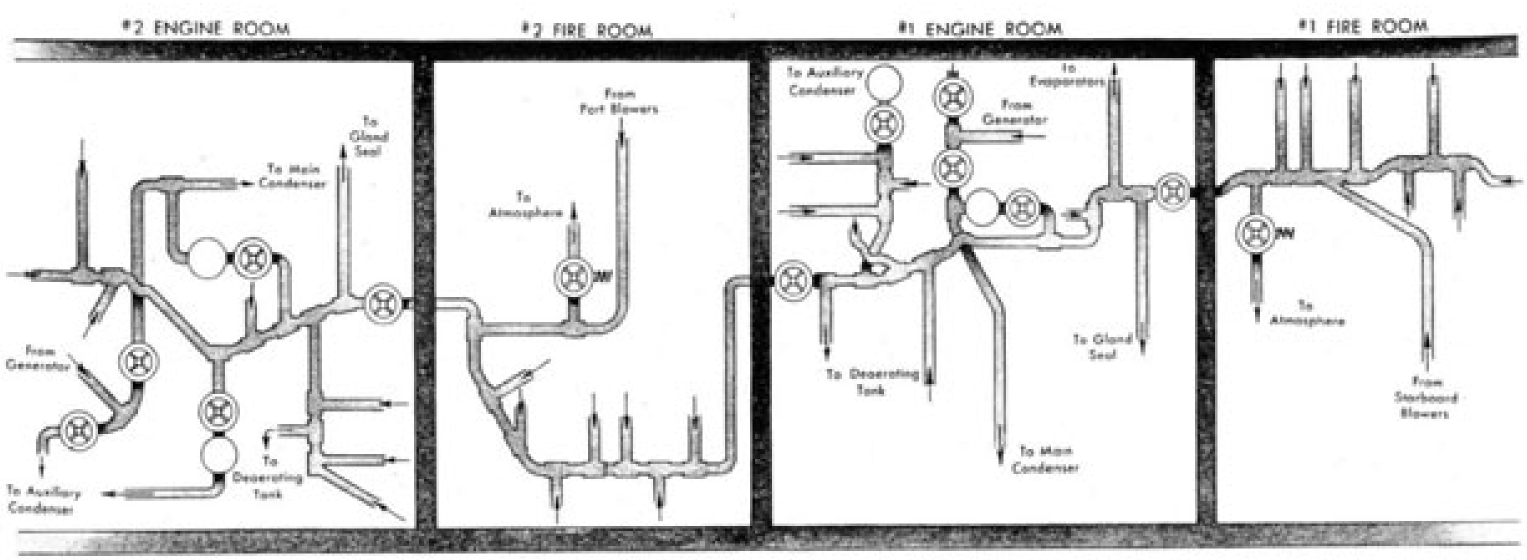

AUXILIARY EXHAUST
FIG. 62

room. The valve at the after bulkhead of the forward engine room divides the system.

(b) The Swartwout Unloading Valve.-This equipment consists of the unloading valve itself, the actuating valve and their connecting piping and valves. Steam inlet is to the bottom, or under the seat, of the unloading valve. The valve is diaphragm-operated. The actuating valve is also diaphragm-operated, and steam pressure is led to the top of this diaphragm from the steam inlet side of the unloading valve. The actuating valve is a double-seated valve, one side of which is closed when the other side is open. When pressure in the auxiliary exhaust line is less than the set pressure the upper seat is closed and the lower seat is open. Steam pressure led from the line acts on the diaphragm and also passes through the valve and then to the bottom of the unloading valve diaphragm through valve *E*. This pressure acting on the unloading valve diaphragm holds the unloading valve closed. When pressure in the Auxiliary exhaust line exceeds the set pressure, the diaphragm in the actuating valve is displaced, closing the lower seat of the actuating valve and opening the upper seat. It is apparent that we then have a direct connection from below the unloading valve diaphragm, through the actuating valve, to the top of the unloading valve diaphragm. Pressure on the diaphragm being equalized, the exhaust line pressure working on the unloading valve disc forces it open and dumps steam into the main or auxiliary condenser. The pressure at which the valve unloads can be adjusted by changing the spring tension against the actuating valve diaphragm. A stem is inserted in the unloading valve below the diaphragm to allow for manual operation. When fully withdrawn this stein has a mushroom which catches a yoke and pulls down the diaphragm to open the valve. Driving the stem fully in causes it to make contact with the diaphragm, forcing the valve closed. In the mid-position the valve is free to operate automatically. Before taking the valve

4. DRAIN SYSTEMS

(a) General Discussion.- There are three drain systems installed in these ships; namely, the high pressure drains, the low pressure drains and the contaminated drains.

(b) High-Pressure Drain System.-The high-pressure drain system consists of a single header in each plant which collects the drains from all high-pleasure lines and leads them into the deaerating tank. The cross-connection is provided between the two systems so that it is possible, under auxiliary operation, to drain the entire plant into one deaerating tank. All the drains leading into this system lead through Yarway impulse traps. These, are constant flow steam traps and their action will be discussed shortly. Since these are constant flow traps the high-pressure drain system must operate under pressure. The discharge from this system leads only into the deaerating tank, and consists entirely of steam. A condition may occur, when securing or when warming up, that will cause the deaerating tank to overheat somewhat because of excessive high-pressure drains entering the deaerating tank. In this case, in order to reduce the deaerating tank temperature it will be necessary to run down some water from the base of the deaerating tank into the main condenser and recirculate it back to the tank through the condensate system. This will cool the water and allow for a greater volume of water to be passed through the tank in order to reduce the tank temperature. When securing, it may be desirable to keep two deaerating tanks in operation for longer than is necessary in order to take care of excessive high-pressure drains.

(c) Yarway Impulse Steam Trap.-The Yarway impulse steam trap is shown in Figure 63A. This is a constant flow trap and allows a continuous flow of steam into the high-pressure drain line as long as its cut-out valves are open. As shown in Figure 63A the valve disc is a piston type disc With a flange at its top and a "control orifice" drilled through it. The

off automatic operation, it is necessary to open the by-pass valve *D* to equalize the pressure on both sides of the unloading valve diaphragm.

Note: If the valve has failed to unload at the set pressure, adjusting the actuating valve will not make it do so. Opening the unloading valve manually without disturbing the actuating valve setting will probably free the unloading valve. Then. when placed back on automatic the valve should operate normally.

piston valve works up and down within a cylinder which is machined with a reverse taper and which is, at its smallest point. the same size as the flange on the valve disc. The position of this cylinder is factory-adjusted so that. with the valve closed, a specific clearance between the flange and cylinder walls is maintained. The area of the control orifice is slightly greater than that of the space between the cylinder and flange. Due to the larger area of the control

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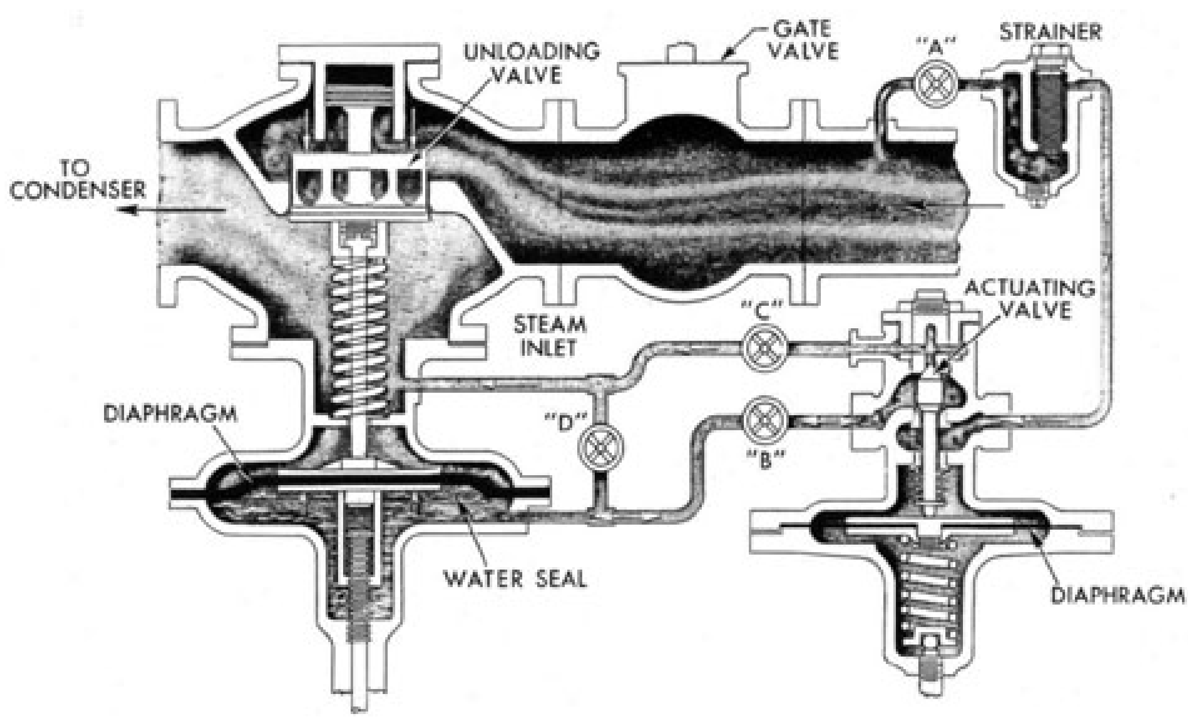

SWARTOUT UNLOADING VAVLE
FIG. 63

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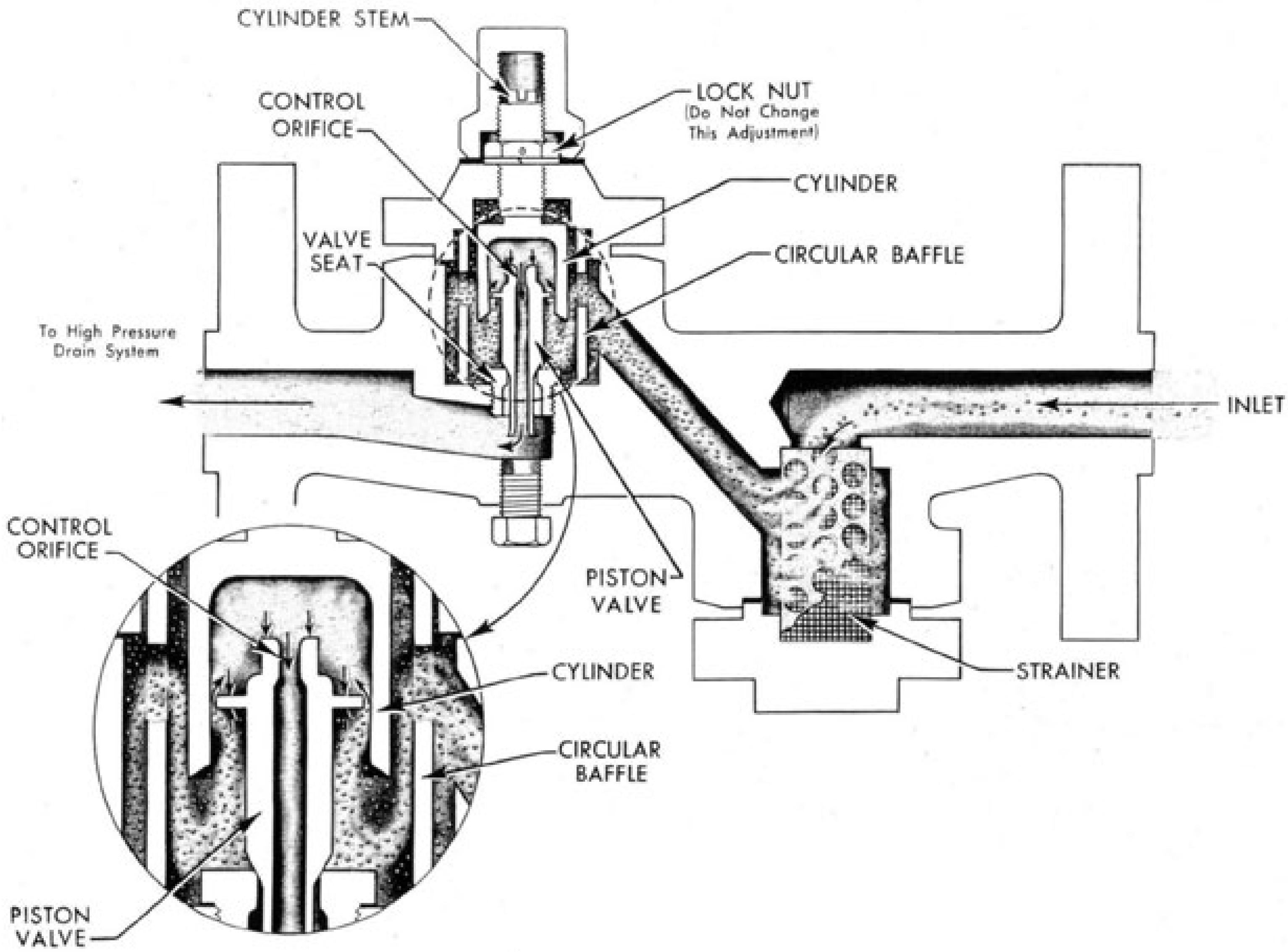

YARWAY IMPULSE STEAM TRAP
FIG. 63a

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orifice, condensate flowing from the steam line when warming up will flow through it faster than it will flow past the flange. This will cause a reduction pressure within the cylinder. When this pressure is reduced to 86 percent of the inlet pressure or less, the force on top of the valve disc is less than the force below the flange and the valve will be forced open. allowing a full flow of condensate through the valve (approximately 1,400 lb. per hr. for a three-fourths inch trap). As the line warms up the temperature of the condensate flowing through the trap increases and as it approaches the temperature of saturated

(d) Low-Pressure Drain System.- The low-pressure drain system consists of a header extending through each plant which collects water from the funnel drains at atmospheric pressure and leads it off into the low-pressure drain tank. There are a few drains which enter this system that do not pass through a funnel namely, the generator gland drains, forced draft blower gland drains (DD445 class) and the after- and gland-seal condenser drains. A cross-connection is provided between the two plants to allow for drainage of all low-pressure drains into either of the low-pressure drain tanks. Attached to the low-pressure drain tank is a float-operated valve,

steam the condensate flowing through the control orifice will start to flash into steam (due to the large drop in pressure through the orifice). This steam having much greater volume than the same quantity of condensate will cause the control orifice to become "choked" up and thereby reduce the flow of condensate. This will cause the pressure within the cylinder to be built up until it is greater than 86 percent of the inlet pressure and the trap will be closed due to the greater area of the top of the disc. With the trap closed, hot condensate or steam will continually flow through the control orifice, discharging into the high-pressure drain line. With 600 p.s.i. pressure to a three-fourths inch trap this amount of constant flow will be approximately 60 lb. per hour. Should a shot of cool condensate enter the trap at any time the same action will occur to drain off the condensate, with the valve closing when the condensate temperature is approximately 30 degrees F. less than the steam temperature. The stein seen attached to the cylinder can be used to raise the cylinder, catching the flange at the base of the taper and manually lifting the valve disc for the purpose of blowing through it to clean off the seat. The lock nut shown is pinned in place. It has been adjusted at the factory to provide the proper clearance between the cylinder and valve flange and should not be moved. The baffle shown shrouding the cylinder and valve disc is placed there to prevent direct impingement of the steam on the cylinder or disc and in addition, provide a guard against possible jet action on the flange. The large flange on the top of the valve is removable and taking it off will remove entirely the cylinder and valve disc, exposing the seat. This will allow for cleaning of the cylinder and grinding of the seat when necessary. The cylinders and disc are interchangeable and in case of damage can be replaced as a unit.

and branches lead from this valve to both the main and auxiliary condensers. When the level in the low-pressure drain tank rises the float causes the float-operated valve to lift and connect whichever condenser may be in use to the low-pressure drain tank. The vacuum in the condenser will then drag water from the tank until the level drops to a point where the valve is again closed. Cut-out valves are located in the branches of the two condensers A frequent casualty in securing is in shifting the low-pressure drain tank from the main condenser to the auxiliary condenser. The valve to the auxiliary condenser is opened but that to the main condenser is not closed, and when the vacuum is dropped on the main condenser it is also lost on the auxiliary condenser. T*hese two valves should never be opened at the same time.* Vents lead from this low-pressure drain tank to the auxiliary condenser and auxiliary air ejector, as well as into the main turbine gland seal exhaust line. The vent line to the gland seal exhaust line should only he used when that system is in operation, otherwise the tank should be vented to the auxiliary condenser or the auxiliary air ejector.

(e) Contaminated Drains.-The contaminated drain system collects the drains from all those services which may, due to leaks, allow oil to get into the system. These drains lead from the fuel oil tank heating coils, the lubricating oil storage and settling tank heating coils and the fuel oil heaters in the firerooms. These are all collected by a single header and must all pass through an inspection tank on the upper level in the engineroom. A cross-connection is also provided to allow for paralleling this system on one inspection tank. From the inspection tank the drains can be led either to the bilge, in case they are contaminated, to the low-pressure drain tank,

or to the deaerating tank. The drains from the fuel oil heaters of the fireroom pass through a drain trap and inspection tank before entering the contaminated drain header. This provides for quick determination as to whether fuel oil heaters are leaking and also allows for maintenance of the seal on the fuel oil heaters. Under most conditions of operation, except in cold waters, the only drains entering the contaminated drain system will be from the fuel oil heaters. At low rates of operation insufficient steam to the fuel oil heaters will not allow for drainage through the inspection tank in the engine room. The water level would have to rise into the heaters to allow for gravity drainage through the inspection tank. Therefore, at these low rates it may be necessary to periodically dump the trap to the bilge in order to prevent the water level from rising into the heaters. This will occasion a certain loss in water but will do away with the excessive carbon formation in the heaters caused when shots of high-pressure steam are used to force drainage. As previously noted, drains from these inspection tanks may go to the deaerating tank, but in this case the pressure in the system must be at least as great as that in the deaerating tank. Therefore, until the pressure is sufficiently great the inspection tank must be drained to the low-pressure drain tank. Under normal operation this drain system and both of the other drain systems would be operated with the cross-connection valves at the after bulkhead of No. 1 engine room closed, to divide the plant.

Previous Section DD Steam Home Page Next Section

Section IX

AUXILIARY PLANT

1. GENERAL DISCUSSION

The auxiliary plant as installed in both the DD445 and DD692 class is just a miniature main plant. It consists of an auxiliary condenser, an auxiliary circulating pump, an auxiliary condensate pump, an auxiliary air ejector and an auxiliary feed booster pump. It uses the deaerating feed tank instead of having a separate auxiliary deaerating feed tank. The operation of each of these units is the same as described with the main plant, except that their capacity is far less. The ship's service turbo-generators exhaust either into the auxiliary condensers or into the main condensers. If exhausting into the main condenser, it is unnecessary to operate the auxiliary plant. When not underway, however, in order to maintain electrical power on the ship an auxiliary plant must always be in operation. Steam piping to the ship's service generators is provided from the main steam system. When getting underway it is recommended that the generator be placed in operation as soon as possible, but it should continue to be exhausted into the auxiliary condenser until the ship has squared away at sea.

2. DD445 CLASS. SHIP'S SERVICE TURBOGENERATORS

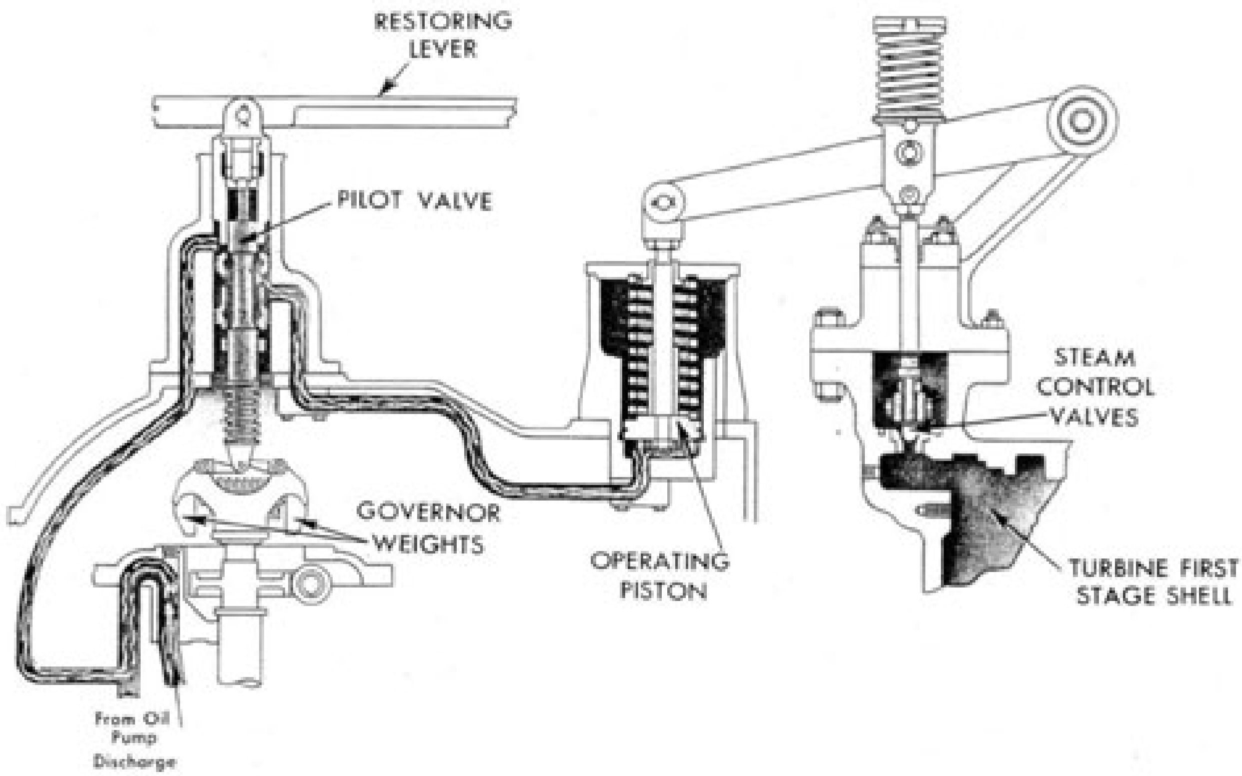
(a) General Discussion.-The Ship's Service generators installed in all DD445 class ships are driven by a six stage horizontal turbine through a reduction gear. They are rated at 290 kw.; 250 kw. of which is at 450 volts AC and 40 kw. at 120 volts DC. The turbine operates at 10,012 r.p.m. which speed is reduced through the reduction gear to 1,200 r.p.m. at the generator shaft. The turbine gear and generator are mounted on a common base, which base forms a lubricating oil sump tank discharges through a cooler and distributes oil throughout the unit. The normal pump discharge pressure is about 50 p.s.i. The pressure is restricted to this level by means of a relief valve which discharges back into the sump. Ahead of the cooler is a control valve which normally should be adjusted to allow the oil delivered to the bearings and sprays of the unit to be maintained at approximately 8 p.s.i. Oil to the governing system comes directly from the pump discharge and is, therefore, under about 50 p.s.i. pressure. A low pressure alarm set for 4 p.s.i. is also provided.

(c) Gland Sealing Steam System.-A gland sealing steam system is provided to seal the turbine glands at both ends. A manifold of three valves, located on the side of the unit, is connected to the auxiliary exhaust line to provide steam for the glands at low loads. The center of these three valves controls the admission of auxiliary exhaust steam. The right hand valve controls the admission of steam to the low pressure gland of the turbine. Under high loads, when sufficient steam bleeds back from the high pressure gland to seal the low pressure gland, the center valve may be closed. When excessive pressure is bleeding from the high pressure gland the left-hand valve should be opened to bleed-off this excess pressure into the third stage of the turbine. Drains from these glands lead into the low pressure drain system.

(d) Constant Speed Governing System.-A governing system is provided which operates to vary the steam admitted to the turbine, in order to maintain constant speed at varying electrical loads. Figure 64 is a diagrammatic representation of this system. The governor weights shown, are connected to the governor pilot valve. Around this pilot valve is located the pilot valve bushing, which is capable of

for the unit. No CMM. MM1/c, MM2/c or MM3/c should be considered qualified to stand an engineroom watch until he can single-handedly warm-up, cut-in, parallel and secure a ship's service generator.

(b) Lubricating Oil System.-A self-contained lubricating oil system is provided for the purpose of supplying oil to all bearings, to the reduction gear sprays and to the governor system. An attached pump takes suction from the sump tank, moving up and down within its housing. The governor weights are connected through a worm and pinion to the reduction gear, and are rotated at a speed of 675 r.p.m. at the turbine rated speed. Centrifugal action of these governor weights causes them to move outward, the degree of motion depending directly upon the speed of rotation. It is apparent from figure 64 that, as these weights move outward the pilot valve itself is pulled down. When the generator



CONSTANT SPEED GOVERNOR
TURBO-GENERATOR
DD 445 CLASS
FIG. 64

is first placed in operation these weights are in their fully down position and the pilot valve is raised to its full height. At this time the restoring lever, which is connected to the pilot valve bushing. will be in its extreme downward position. This will cause the pilot valve bushing to be in its downward position while the pilot valve itself is in its upward position. Oil is led directly from the oil pump discharge to the upper ports of the pilot valve bushing. With the pilot valve up and the bushing down these ports are open, and oil can then flow through the ports directly to the base of the operating piston following the path shown in Figure 64. Of course with the generator at rest there is no discharge pressure from the attached oil pump. In order to lead pressure to the pilot valve when starting the generator it is necessary to operate the hand pump. Putting pressure on the base of the operating piston will force it upward in its cylinder. When this occurs the rocker arm shown connected to the operating piston, will rise and carry with it the connecting rods which actuate the steam control valves. The six steam control valves have their sterns passing freely through a crosshead. Collars, on the top of each stem, are staggered in height so that, as the cross-head is lifted by the connecting rods it lifts successively each steam control valve. With the steam control valves open, steam is admitted directly to the turbine steam nozzles, rotating the turbine. As the turbine speed increases the governor weights move outward and, in moving outward cause the pilot valve to be drawn down. As the valve is drawn down it closes off the upper port of the pilot valve bushing thereby cutting off the oil supply to the operating piston; but, since the system between the pilot valve and operating piston is entirely closed, the pressure previously built up will remain in that system, holding the operating piston at whatever height it may have risen to. As the turbine speed rises too high the pilot valve continues to be lowered. This causes the lower ports of the bushing to be opened while still keeping the upper ports closed. This allows pressure to bleed from the operating piston, dumping the oil into the reduction gear case. As

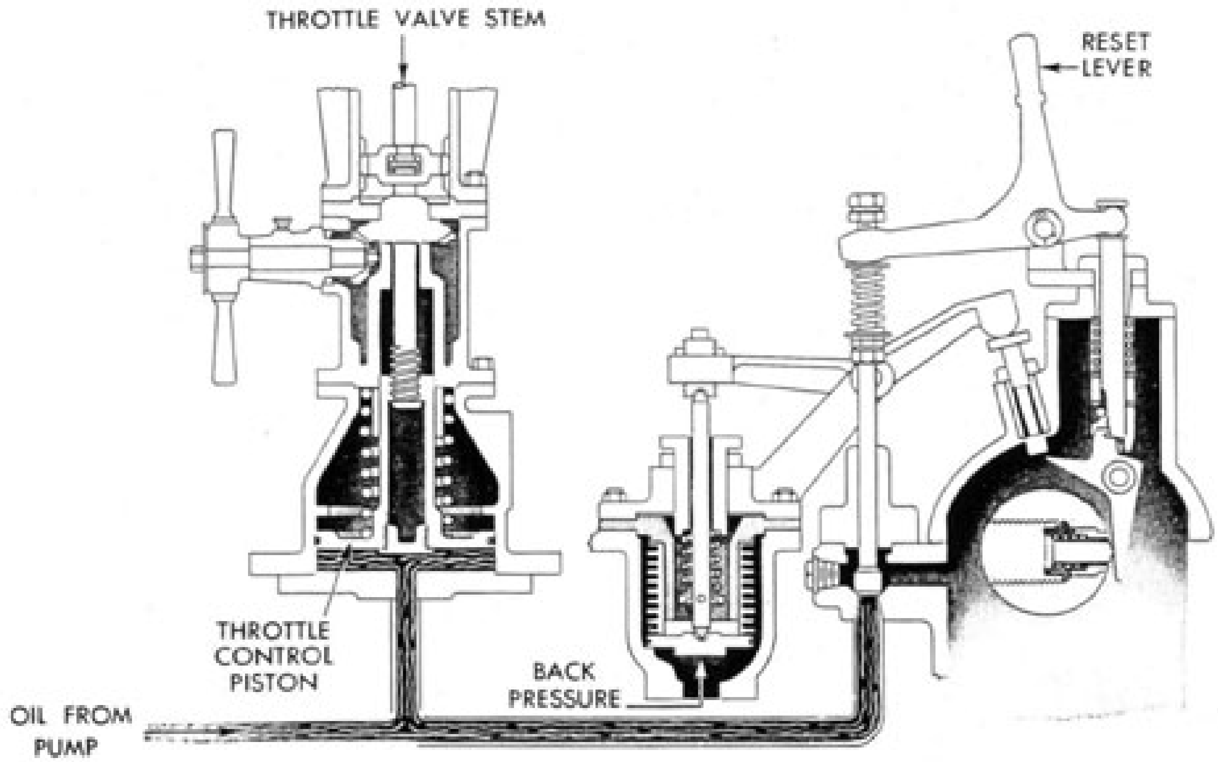
this pressure is reduced the operating piston moves downward thereby reducing the opening of the steam control valves. When the turbine is again at its proper speed the low port will be again closed and, with the tipper port closed, the governor system will be in a condition of stability with the proper pressure maintained on the operating piston to cause sufficient opening of the steam control valves to maintain the turbine rated speed. Should the load increase this would cause the turbine to tend to slow down. This slowing will allow the governor weights to move inward and raise the pilot valve. Raising the pilot valve will again open, partially, the upper port of the pilot valve bushing and allow more pressure to he transmitted to the operating piston, thereby bushing to vary the speed which the governor will maintain.

The governed speed of the turbine may also be electrically controlled from the switchboard by means of the synchronizing device motor which is connected through a small gear train to the lower end of the stem of this handwheel.

(e) Throttle Valve.-The throttle valve installed with this generator does not directly control the flow of steam to the turbine chest. The flow of steam is controlled by the steam control valves located between the throttle valve and the turbine chest, which are operated by the governor mechanism. The throttle valve only admits steam tip to the control valves. This

admitting more steam to the turbine and restoring it to normal speed. The restoring lever is connected to the steam control unit connecting rods and as those connecting rods rise, admitting more steam, the restoring lever also rises and carries with it the pilot valve bushing. This brings the bushing up to a position where the upper port is again closed off, leaving the system again in a stable condition. As the load decreases the speed will tend to increase, causing the governor weights to move further out. This will pull down the pilot valve, opening the lower port of the pilot valve bushing and allow pressure from the operating piston to bleed off, thus reducing the opening of the steam control valve. As the steam control valves are closed the restoring lever is also moved downward. moving the pilot valve bushing down and causing the lower port to be closed off; again restoring the stability of the governing system. Thus we see that the degree of opening of the steam control valves depends upon the relative positions of the pilot valve and pilot valve bushing the pilot valve being the speed control part of he governor and the bushing having its position varied depending upon the load. Of course, under no-load conditions varying the position of the pilot valve bushing will vary the speed, but where two generators are operating in parallel varying of the location of the pilot valve bushing will not change the speed but will change the percentage of total load carried by that particular generator. At the left-hand end of the restoring lever is provided a hand wheel and threaded stem, the operation of which will cause that end of the restoring lever to move up or down, thus moving the pilot valve throttle valve is so arranged that it cannot be opened unless oil pressure from the hand pump discharge or from the attached oil pinup discharge is led to its control piston. Therefore, it is apparent that in order to allow steam to pass to the steam control valves, the hand pump must first be operated, not only to actuate the governor mechanism but also to force open the throttle valve. A hand wheel is attached to this throttle valve. Unless oil pressure is being discharged to the throttle control piston. operating this hand wheel cannot cause the throttle valve to open. In figure 65 this handwheel is shown operating through a bevel gear to turn the lower portion of the throttle valve stein. This lower portion of the throttle valve stem is threaded into the throttle control piston. In the position shown in figure 65 this stem is all the way up in the piston and, when oil pressure is placed on the bottom of the piston to move the piston up, it will carry the stem with it and open the throttle valve. If the hand wheel is so operated as to run the thread down through the throttle control piston, this will cause the throttle valve disc to be moved downward and close off without moving the throttle control piston. This thread can be adjusted to give any desired degree of opening of the throttle valve. However, with no oil pressure on the throttle control piston. turning this hand wheel will merely cause the piston to be raised or lowered without moving the throttle valve disc. Thus it can be seen that unless oil pressure is placed on the throttle control piston the throttle valve itself cannot be opened to admit steam to the steam control valves.

(f) Emergency Tripping Device.-The oil-operated feature of this throttle valve is utilized in the operation of the emergency tripping device.



OVERSPEED AND BACK PRESSURE TRIP
445 CLASS
FIG. 65

A small weighted plug is located in the end of the turbine shaft and inside the forward bearing housing. Figure 65 illustrates the method of insertion of this plug in the shaft. A bell crank pinned in its center and capable of rotating about this pin is also located within the forward bearing housing. A vertical push rod (Fig. 65) rests on a minute ledge on this bell crank when the tripping device is in the set position. Connecting from this push rod to a valve stem is a rocker arm which, when the device is in the set position, holds the valve stem down and the valve consequently closed. Oil pressure from the same line which supplies the throttle control piston is led to the base of this valve. As the speed of rotation of the generator shaft increases to its tripping speed of 1,320 r.p.m., the plug in the shaft has sufficient centrifugal force to overcome the force of the spring working against its base flange. At this speed the plug will tend to move outward from the shaft and, in doing so strike the lower end of the bell crank. This causes the bell crank to rotate around its axis and allow the push rod to slip off of the minute ledge upon which it rests. Dropping this push rod actuates the rocker arm and allows the valve to lift. The outlet side of this valve is connected into the open housing as shown, and, when the valve lifts, the oil pressure is released, releasing also the oil pressure on the throttle control piston and causing the throttle valve to be dosed by the action of the spring working on top of the piston. A back-pressure tripping device is also provided to cause the generator to trip out when the exhaust pressure from the generator reaches a level of from 6 to 9 p.s.i. gage. The exhaust pressure from the turbine is led into a bellows. The bellows is connected to a push rod which operates another rocker arm. The opposite end of this rocker arm rests against a button which extends through the forward bearing housing to just miss

making contact with the opposite end of the bell crank. When the back pressure becomes excessive it causes the bellows to be squeezed together, raising the push rod and forcing the rocker arm down against the button, thereby causing it to make contact with the bell crank arid displace it. This causes the same action as previously described in connection with the overspeed trip, dumping pressure from the throttle control piston and closing the throttle valve. *Under no circumstances should the tripping device be reset without first operating the throttle valve handwheel to run down the valve stem through the operating piston so that the throttle valve cannot be opened.* This will prevent the throttle valve from suddenly slamming wide open when the reset lever is operated, closing off the tripping valve. If this should happen a shot of water could very easily be allowed to enter the turbine. The trip can he reset when the generator speed has dropped 100 r.p.m. below normal. Then, operating the throttle valve handwheel will allow the valve to be opened slowly instead of suddenly. Whenever the generator is to be shut down it should be done by pressing down on the button end of the back pressure rocker arm, thus causing the generator to be manually tripped out. It is desirable whenever first starting a generator to always bring it up to its tripping speed and cause it to trip out, in order to test the operation of the overspeed trip. In any case these trips should be periodically operated in order to prevent the moving parts from becoming frozen, and consequent failure in an emergency.

3. DD692 CLASS, SHIP'S SERVICE, GENERATORS

(a) General Discussion.-The ship's service generators installed in the DD692 class ships are p.s.i. instead of the 4 p.s.i. required in the DD445 class.

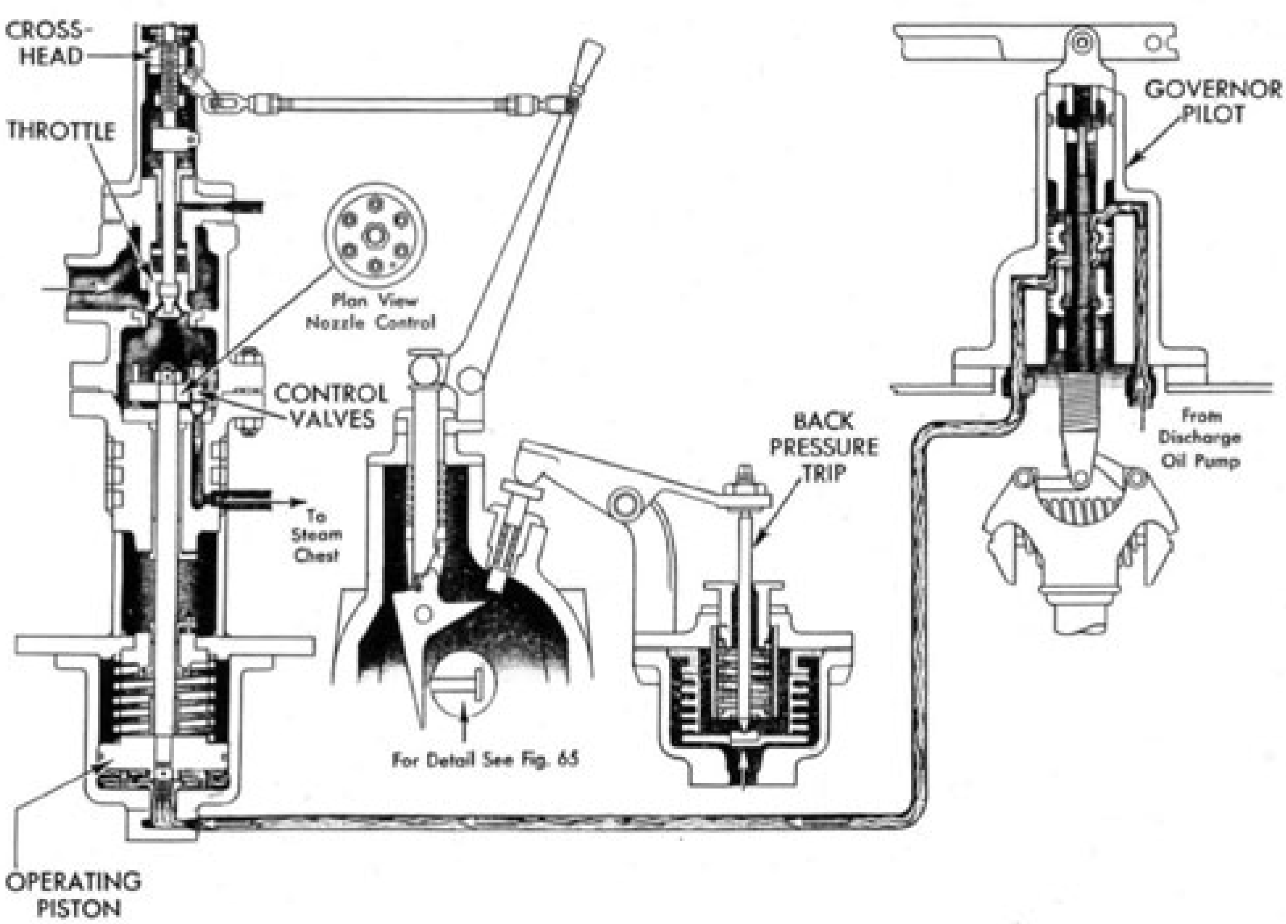
(c) Gland Sealing Steam System.-The gland sealing steam system is practically the same as that described for the DD445 class. The valve manifold, however, appears at the forward end of the generator turbine instead of on the side, and the bleeder valve, used to exhaust excessive pressure, discharges into the turbine exhaust instead of the third stage.

(*d) Governor Mechanism*.-The arrangement of the governor pilot valve and pilot valve bushing, together with its operation, is the same as that described in connection with the DD445 class governor mechanism. However, the arrangement of the steam control valves and the operating piston is considerably different. This is readily apparent in figure 66. The governor operating piston has a piston rod attached to it which carries a circular cross head at its upper end. Passing through this circular cross head are the six steam control valves which admit steam to the turbine steam nozzles. The plan view shown on figure 66 indicates that these valves are located in a circle through this cross head. The nuts shown on the control valve stems above the cross head are staggered in height so that raising the cross head will successively open the control valves. A change in the oil pressure passed to the operating piston by the governor pilot valve and bushing will cause the piston to be raised or lowered, carrying with it the cross head, which in turn causes the control valves to open or close successively. Steam is led from the control valves to the turbine chest through three separate external pipes. In all other respects the operation of the governor mechanism is the same as that previously discussed. Since the restoring lever, connected to the pilot valve bushing, cannot be directly connected up to an external lever, as in the DD445 class, it is

of a similar design to those previously discussed for the DD445 class, but are of much greater rating. The generator is rated for 400 kw. at 450 volts AC. and 50 kw. at 120 volts DC.; making the total power of the generator 450 kw. The generator is driven at 1,200 r.p.m. by a turbine connected to it through a reduction gear. The rated turbine speed is 10,059 r.p.m., the gear ratio being slightly greater than that in the DD445 class generator.

(b) Lubricating Oil System.-The lubricating oil system of this generator is exactly the same as that described for the DD445 class generator, with the sole exception that the low-pressure oil alarm is set to operate when the oil pressure drops to 5 connected to the operating piston rod through a series of connecting levers. which effectively transmit the motion of the operating piston back to the pilot valve bushing, causing the same action as described for the DD445 class governor.

(c) Throttle Valve.-The throttle valve for this class differs considerably from that installed on the DD445 class generators. This is not an oil-operated throttle valve. Figure 66 shows this valve located just above the control valve cross head, and in the same housing. The stem of this throttle valve passes through a cross head.



GENERATOR GOVERNOR AND TRIPS
692 CLASS
FIG. 66

as indicated in figure 66, and then leads on up to a handwheel. A strong spring works down at all times against the cross head. In order to cause this throttle valve to open by turning the handwheel, the cross head must be held stationary and prevented from moving along the thread, otherwise turning the handwheel would merely run the cross head up or clown on the thread and not affect the throttle valve. In order to hold this cross head stationary a toggle shown setting in a notch in the lower right-hand corner of the crosshead, is provided. This holds the cross head up against the spring pressure, and when the throttle handwheel is turned the cross head. being unable to move, remains stationary; and the valve stem rises or chops through it, thereby causing the throttle valve to open or close. The toggle has a lever attached to it which is in turn connected to the emergency tripping device of the generator. The only time that this toggle can be engaged in the notch of the cross head is when the throttle valve handwheel is in the fully closed position. To engage the toggle, the emergency tripping device must be set. This means that the emergency tripping device cannot be placed in the set position unless the throttle valve is closed, and it also means that the throttle valve cannot be opened unless the emergency tripping device is placed in the set position to hold the cross head stationary.

(f) Emergency Tripping Device.-Except for its method of closing the throttle valve the emergency tripping device attached to this generator is the same as that discussed in connection with the DD445 class generator. The same plug is inserted in the generator shaft, which, when the turbine overspeeds, strikes the bell crank, causing the push rod to drop from the ledge on which it rests. From here on the action differs slightly, in that dropping this push rod causes the handle (fig. 66) to move forward suddenly. This handle is connected, by a connecting rod, to a lever, which is attached to the throttle valve toggle. When the handle moves forward suddenly it carries with it the connecting rod, causing the lever to be turned and consequently turning the toggle out of the notch in the cross head. This frees the cross head and allows the spring pressure, above the cross head, to push it down, carrying down the throttle valve stem and closing off the throttle valve. In this position the cross head is now below the toggle, and in order to re-set the toggle the cross head must be returned to its upper position. Turning the throttle valve handwheel will turn the stem through the cross head and, since the stem cannot move up and down, the valve being already closed, the cross head rises on the threads. When the handwheel is in the fully closed position the cross head will be at its raised location, allowing the toggle to be re-set in the notch. To do this requires re-setting of the tripping mechanism. The back-pressure trip attached to this emergency tripping mechanism is, on this generator, set for 5 p.s.i. back pressure. It consists of a bellows similar to that on the DD445 class generator. which operates through a rocker arm to press a button, displacing the bell crank in the bearing housing. This action is the same as that described with the DD445 class and, following through, causes closing of the throttle valve as described in connection with the overspeed trip.

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Section X

AUXILIARY MACHINERY

1. DISTILLING PLANT

(a) General Discussion.-The distilling plant is a low-pressure, double-effect, single-shell, submerged-tube type with a rated capacity of 12,000 gal. per day of distillate having a chlorine content not exceeding one-fourth grain per U.S. gallon with first-effect steam at a pressure not exceeding 5 p.s.i. gage, distilling condenser vacuum 26 inch Hg., and brine overboard discharge density 1 1/2 thirty-seconds. The double-effect unit consists of a horizontal cylindrical shell containing the evaporating units, vapor feed heater, distilling condenser, baffles, vapor separator and associated fittings. A vertical wall divides the two chambers. The first-effect chamber contains the first-effect evaporating unit, the vapor feed heater and a vapor separator. The second-effect chamber contains the second-effect unit, the distilling condenser and a vapor separator. Distilling condenser vacuum is maintained by a single-stage air ejector discharging into a condenser cooled by evaporator feed. Automatic control of the tube drains is maintained by externally mounted drain regulators.

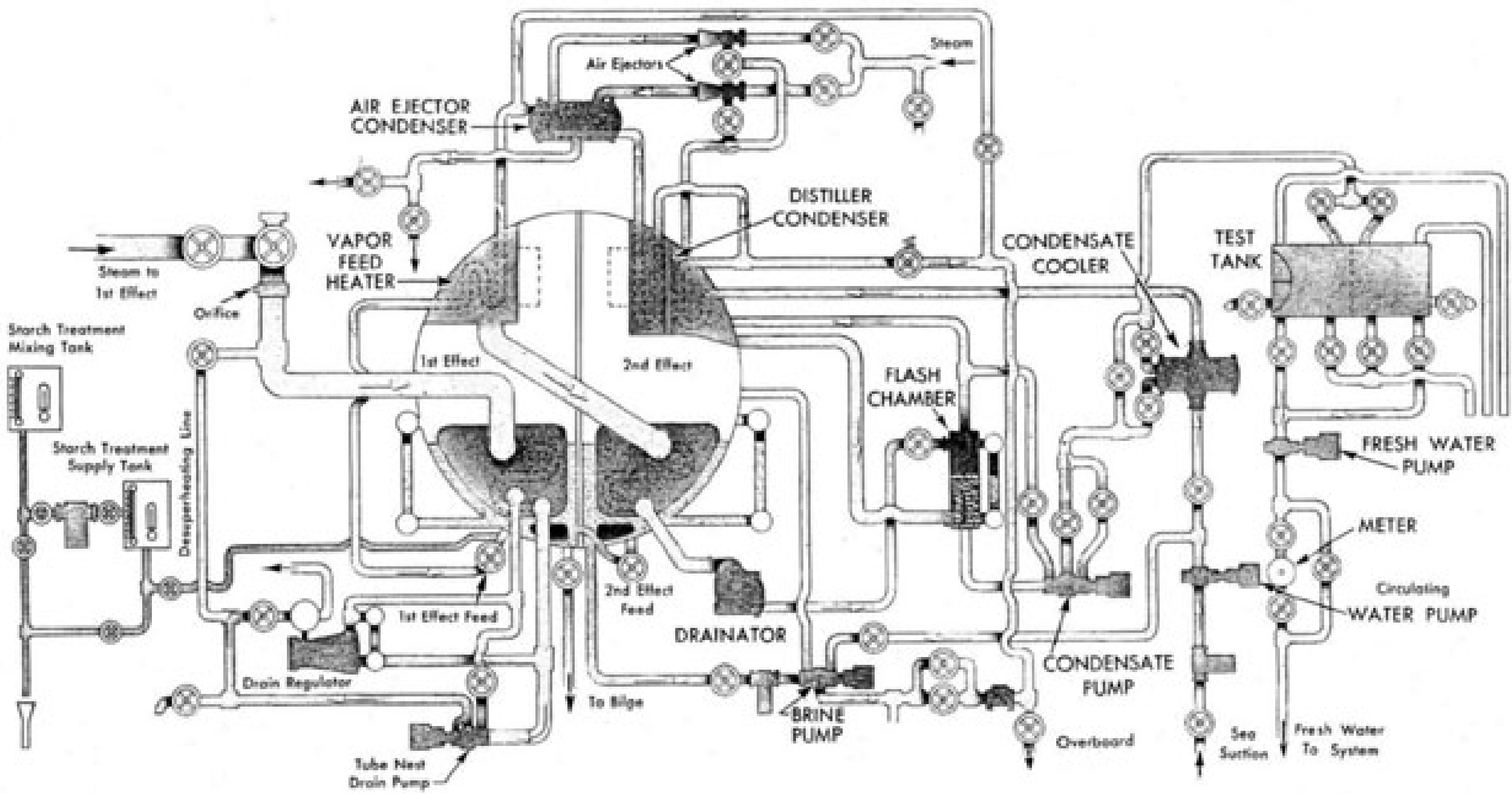
(b) Cycle of Operation.-The distilling condenser circulating pump takes a sea suction and discharges through a distillate cooler to the cooling passes of the distilling condenser and then overboard. The evaporator feed pump takes its suction from the overboard discharge line and discharges the feed through the heating passes of the distilling condenser, through the air ejector condenser, vapor feed heater and to the first-effect chamber. The pressure differential between the first- and second-effect chambers allows the feed to flow from first to second effect. The brine is continually discharged overboard from the second effect by the brine discharge pump. Steam for the pipe to the second-effect tubes. Second-effect tubes drain through a drain regulator to a flash chamber where its pressure is reduced to that of the distilling condenser. The resulting flash vapor discharges to the distilling condenser, and the remaining distillate drains to the evaporator condensate pump. Vapor from the second-effect passes through baffles and separator to the distilling condenser. Distillate from the condenser combined with the flash chamber drains goes to the condensate pump which discharges it through the distillate cooler to the test tank from which it is pumped to feed or ship's tanks. The first and second-effect tube nests have vent connections through controlling valves to the second-effect shell. Electrical salinity cells are fitted in the first and second-effect tube nest drain lines, the distilling condenser drain, the fresh water pump discharge and in the air ejector condenser drain. Following is a brief description of the major units in the distilling plants:

(e) Evaporator.-Tube bundles are of five-eighths-inch outside diameter tubes arranged for two passes of the heating steam. Expansion of the tube nest is provided for by supporting the back tube sheet and the intermediate supporting plate on rails in the shell.

(d) Vapor Feed Heater.-The vapor feed heater is of the straight tube type with five-eighths-inch outside diameter tubes expanded into a tube sheet at each end and supported by an intermediate support plate.

(e) Distilling Condenser.-The distilling condenser is of the straight tube type with five-eighths-inch outside diameter tubes. A portion of the distilling condenser is arranged by means of a suitable baffle to serve as a precooler for the air going through the air ejector suction. The circulating water makes two passes through the condenser before discharging overboard. The portion of the circulating water

first-effect tubes is obtained from the auxiliary exhaust line through a reducing valve. The first-effect tubes drain through a drain regulator to either the ship's condensate system or to the L.P. drain tank. Vapor from the first-effect passes through a series of baffles and a vapor separator to the vapor feed heater, and through an external needed for feed is pumped from the overboard line by the feed pump and discharged through a separate connection back to the condenser where it makes three more passes before discharging to the air ejector condenser.



SOLOSHELL LOW PRESSURE DISTILLING PLANT
FIG. 67

(f) Air Ejector Condenser.-The air ejector condenser is of the straight tube, counterflow type with five-eighths-inch outside diameter tubes. The air ejector steam makes five passes through the shell, and the feed makes three passes through the tubes.

(g) Air Ejector.-Two air ejectors are provided, one for operation and one for spare. The ejectors are of the single-stage type with the gases entering the inlet of the ejector at the mixing chamber being entrained with the steam from the nozzle and being carried through the diffuser where they are compressed to atmospheric pressure. From the diffuser the gases are discharged into the after condenser in which the heat is absorbed by the evaporator feed.

(h) Flash Chamber.-The flash chamber is a receptacle in which the second-effect drains are reduced to a pressure and temperature corresponding to the distilling condenser vacuum. It is attached to the second-effect side of the evaporator shell.

(i) Tube Nest Drain Regulator.-The first-effect tube nest drain regulator is of the external valve, ball float type. The valve is located in the discharge line of the drain pump and is provided with a bypass valve for operation if the regulator becomes inoperative. The tube nest drain regulator for the second-effect is of the piston type balanced valve with ball float. The regulator can be locked openm and manual control of the drain level is then accomplished.

(j) Distillate Cooler.-The distillate cooler is of the straight-tube type with five-eighths-inch outside diameter tubes. The distilling condenser circulating water serves as the cooling medium for the condensate.

(k) 4,000 Gallons Per Day Plant.-In addition to the 12,000 gallons per day distilling plant in the forward engine room, the D1D692 class ships a motor-driven compressor, (*b*) condensation of the gas by water-cooled condenser, (*c*) expansion of liquid refrigerant by thermal expansion valve, and (*d*) evaporation of low-pressure liquid refrigerant by absorption of heat in evaporators. The compression of the refrigerant gas permits condensation at the temperature of the condensing water. The refrigeration is accomplished by expanding and evaporating this liquid refrigerant. The absorbed latent heat of evaporation and superheat is removed from the refrigerant gas by again compressing and then condensing to the liquid state. The process is repeated continuously. Freon is a noncombustible, nontoxic, nonirritating, nonexplosive, noninflammable, noncorrosive refrigerant which is a liquid when under a 75 p.s.i. pressure. It is shipped as a liquid under pressure in steel cylinders. The refrigerating equipment consists of three essential parts:

(a) Compressors.-Two Carrier 7H5 Freon compressors, either of which can carry the entire load, are installed. The other compressor is used as a spare. They are vertical, reciprocating, single-acting, multiple **V**-belt driven by a two-speed 7 h. p. motor. Each compressor has a capacity of 2 tons of refrigeration per 24 hours.

(b) Condensers.-Each compressor is provided with a separate water-cooled Freon condenser. A separate refrigerant receiver is provided for each condenser, and these receivers serve as a reservoir for load surges. A water regulating valve is provided in the condenser water inlet and is actuated by the Freon head pressure in the refrigerant inlet line to the condenser. This automatically regulates the flow of condensing water to the condenser. A water pressure failure switch is provided in the condenser water inlet line to the condenser which stops the compressor in case of a failure in condenser water supply and permits the compressor to start again when water pressure is restored.

(c) Evaporators.-The refrigerated compartments are provided with 1 5/8 inches outside diameter copper

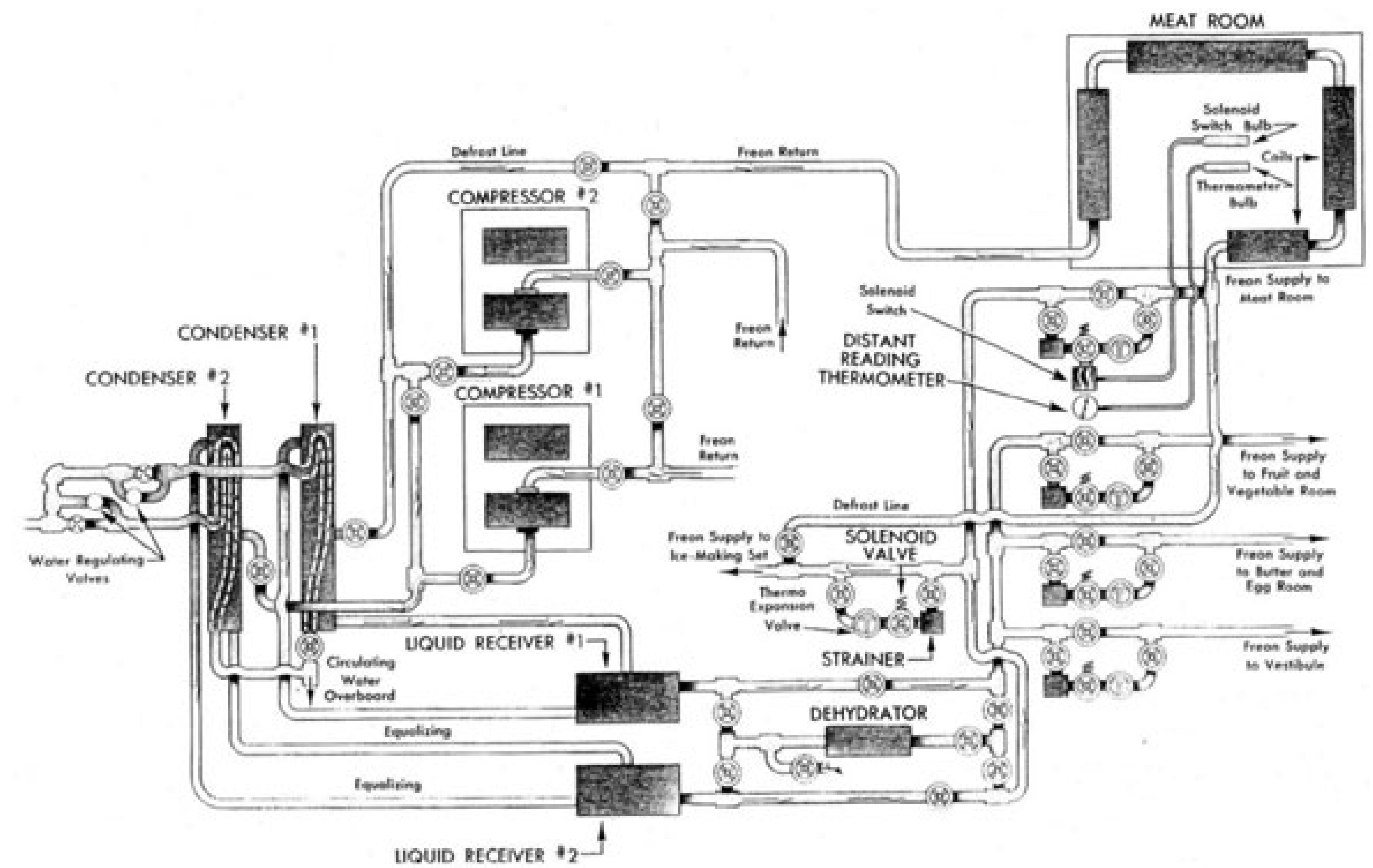
have a 4,000 gallons per day plant installed in the after engine room. This plant is similar in all respects to the 12,000 gallons per day plant described, differing only in size and capacity.

(l) Corn Starch-Boiler Compound Injection System.-By Shipalt DD447 the installation of a cornstarch-boiler compound injection system and a fixed internal spray pipe in the first-effect shells (for cold shocking the coils) was authorized for all destroyer distilling plants.

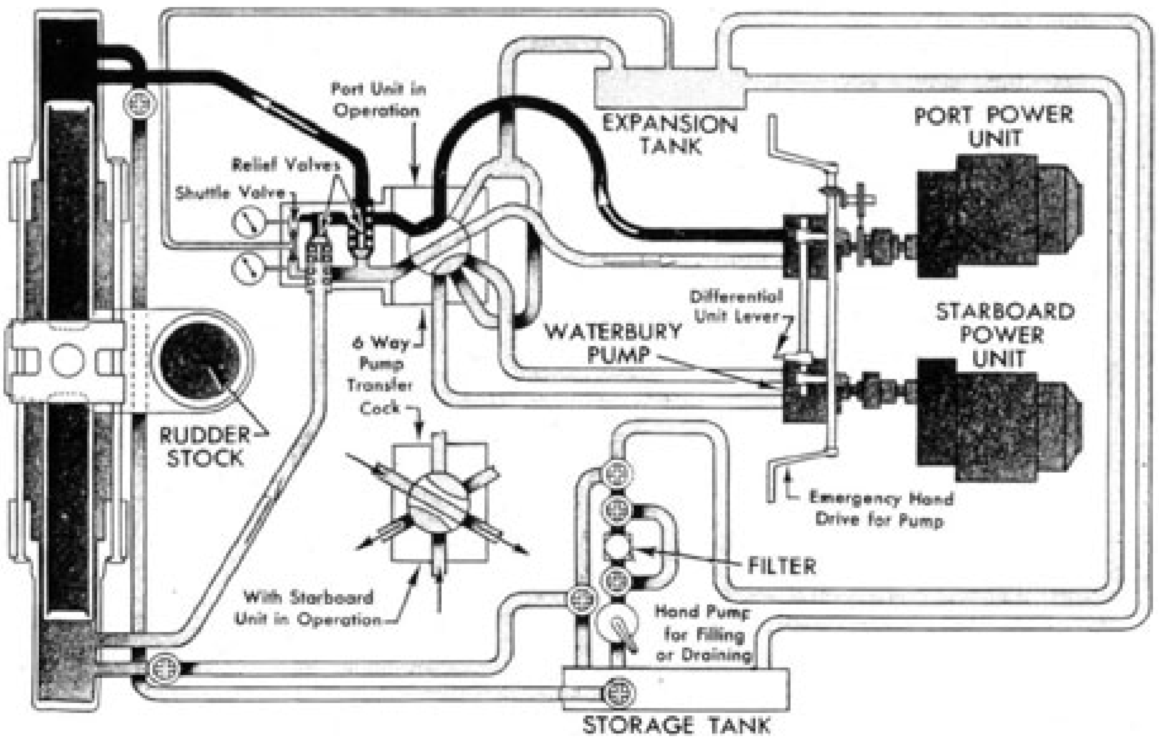
2. REFRIGERATING PLANT

The refrigerating cycle is essentially composed of four steps: (*a*) compression of Freon gas by tubing coils which contain sufficient cooling surface to maintain the following temperatures:

Meat room, 15 degrees.
Butter-Egg, 32 degrees F.
Fruit-Vegetable, 40 degrees F.
Vestibule, 40 degrees F.
Ice Set, 15 degrees F.



REFRIGERATING SYSTEM
FIG. 68



ELECTRO-HYDRAULIC STEERING GEAR
FIG. 69

Separate circuits are provided so that all any one circuit may be cut out without interfering with the remainder. The refrigerant cycle operates in general as follows: The compressor withdraws the gaseous refrigerant from the evaporators and delivers it to the condensers which extract heat from the refrigerant and condense it to a liquid. The cooled liquid under pressure flows to the refrigerated compartments in which a reduced pressure is maintained in the coils, which causes the liquid to evaporate and to absorb heat from the air or bring it in contact with the cooling coils. The liquid refrigerant is passed through a thermal expansion valve before entering the cooling coils. The thermal expansion valves control the quantity of liquid refrigerant that passes to each circuit and maintain a constant degree of superheat of the gas leaving the evaporators. thus preventing liquid refrigerant from surging back to the compressor. The solenoid refrigerant valves actuated by temperature control switches cut off the supply of liquid refrigerant to the thermal expansion the desired temperature. Suction pressure regulating valves are used in the compressor suction lines from the 32 degrees F. and 400 F. rooms to prevent excessive difference in temperature between the compartment and the refrigerant in the evaporators which would result in dehydration of the materials stored. Other features of the refrigerating system include high- and low-pressure control switches, strainers, dryers, and an external relief valve.

3. STEERING ENGINE

The steering gear is of the hydroelectric, Rapson slide and follow-up type. It is equipped with a full storage motion control unit. In consists essentially of a ram working in two cylinders, and connects hydraulically to two variable-stroke Waterbury pimps either of which may be in operation. The ram operates the rudder through a tiller fitted with sliding blocks. Remote control of the steering gear is accomplished by a Westinghouse Electric transmission system. The steering stand in the pilot house includes a

valves when the refrigerated compartments reach

synchronous control transmitter to control a synchronous

receiver located in the steering gear room and geared to the pump stroke control rods. The receiver is geared to, and actuates one end of the differential control unit, the other end of which is operated by the movement of the rudder. This movement is taken from the tiller through gears. and is uniform at all rudder angles. Direct local steering control is provided in the steering engineroom by a disk type trick wheel. It is the differential control unit which establishes a single and common control of the follow-up, full storage motion type for the pumps so that the stroke of each may be varied locally and remotely. The full storage motion feature allows the control to lead the rudder by the full amount of rudder travel from hardover to hardover, or, in other words, makes it possible for the rudder and control to be out of step by the full rudder travel without damage to either the control or follow-up. Each power plant consists of a continuously running Westinghouse gear motor connected through a flexible coupling to a Waterbury variable stroke hydraulic pump. Emergency steering is accomplished by means of two hand cranks. These cranks drive the port pump by means of gears and roller chains. When the cranks are in use, steering control is accomplished in two ways, one of which is by use of the trick wheel while the cranks are being turned continually over the top toward the plunger unit. The other results from putting the pump on a fixed stroke and turning the cranks in either direction according to the rudder motion desired. A pump control hand lever (keyed to the pump control shaft which in turn carries levers controlling the pump stroke) is normally pinned to the differential control lever. To put the pump on a fixed stroke the locking pin is drawn and used to lock the lever to a fixed quadrant on the other side of the shaft at 20, 40, or 60 percent of the full stroke of the pump. A six-way plug cock normal. A shuttle valve, the double function of which is to vent the hydraulic system and also act as a means of replenishing the oil supply, is installed at the highest point in the pressure piping. It is connected to the expansion tank which in turn has connections to the main pumps for the purpose of oil circulation and also to a hand pump for filling the system from the storage tank. The motors, pumps, differential control unit, synchro-tie receiver, hand crank stands, trick wheel stand, transfer valve, shuttle valve, expansion tank, and their respective assemblies are mounted on a common bedplate which is so constructed as to make an oil storage and drain tank for the hydraulic system.

DD692 Class.-Since the DD692 class is equipped with a double rudder, the connection of the ram to the tillers of the rudders is different from that shown for the DD445 class. Two tie rods lead from the rain cross head to each of the tillers which are located outboard of each end of the ram. Thus, a motion of the cross head is transmitted simultaneously to both tillers.

4. EMERGENCY DIESEL GENERATOR

The emergency Diesel generator set includes a 2-cycle, 3-cylinder General Motors Diesel engine; a 100-kw. 0.60 or 0.80 p.f. 450-volt, 3-phase, 3-wire, 60-cycle, 1,200 r.p.m. A. C. generator; a 2.25-kw., 120-volt, 1,200-r.p.m. D.C. exciter, directly connected to the generator; a voltage regulator for regulating the voltage of the A. C. generator; a generator field discharge resistor; an exciter field rheostat, and one engine starting motor control equipment. The 6 1/2 x 7 Diesel engine has a unit injector, a self-contained hydraulic governor, and four attached pumps, namely: A Northern fuel oil pump delivering 0.8 gallon per minute at 1.906 r.p.m., and 40-50 p.s.i. discharge pressure, a General Motors

installed in the pressure piping between the pumps and the cylinders and controlled by a hand lever permits hydraulic connection between the cylinders and the pump in service and automatic by passing of the idle pump. Lugs on the plunger contact renewable copper crushing pieces on the tie rods when the rudder reaches the 35 1/4 degrees angle and cushion the shock before contact is made with positive steel stops which limit the angle to 36 1/2 degrees. The steering gear is protected from abnormal stresses by a relief valve set for an oil pressure 10 percent plus 50 p.s.i. higher than the maximum lubricating oil pump delivering 24 gallons per minute at 1,200 r.p.m.. and 35-40 p.s.i. discharge pressure; an Ingersoll Rand pump delivering 85 gallons per minute of sea water at 2,492 r.p.m.; and an Ingersoll Rand fresh water pump delivering 50 gallons per minute at 2,492 r.p.m. Following are some of the more important features of the Diesel engine: The injector is of the unit injector type in which the spray valve and pump are made up into a single, compact unit, and each engine cylinder is provided with a complete and independent injection system. The injector is seated in a tapered hole

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in the lower deck plate of the cylinder head and is guided in the upper deck plate by a short land on the spray valve nut. A holding-down clamp secures the injector in the cylinder head. The cylinder load is controlled by a rack which extends horizontally from a guide bore in the injector body. A rack adjustment on an injector control link connection permits regulating the load of each cylinder while the engine is running. The injector plunger is operated through a constant stroke by a rocker lever from the injection cam on the main cam shaft. The engine speed is held uniform for any setting of the governor. The movements of the governor power mechanism are transmitted through lever and link connections to an injector control shaft. When the engine speed becomes excessive, an overspeed trip mechanism stops the injection of fuel oil into the combustion chambers. The camshaft gear is fitted with a spring loaded flyweight. Centrifugal force moves the flyweight against the spring, until at the overspeed the flyweight trips a latch, releasing a spring-actuated injector lock shaft in the cam pocket. The overspeed trip is manually reset with a hand lever. A long shaft through the crankcase transmits power from the camshaft drive to another gear train which drives the blower, the two cooling water pumps and the lubricating oil displacement type with spur gear rotors and is driven from the camshaft gear train. The pump draws fuel from a supply tank, forces it through a filter to the fuel supply manifold, and delivers it through individual cylinder filters to the injector where surplus fuel is bypassed. Injector drainage returns to a separate manifold in the multiple oil pipe assembly. A constant pressure is maintained in the fuel supply manifold. The lubricating oil pump is of the positive-displacement, helical spur gear rotor type, and draws hot oil from the oil pan and delivers it through a strainer, relief valve, filter, and cooler to the engine lubrication system. The engine is automatically started when the voltage of the ship's service supply falls below 350 volts in the DD445 class or 290-volts in the DD692 class. When the engine starts firing the starting motor is unloaded and is disconnected from the battery. Normal operating conditions call for lubricating oil temperature of 165 degrees F., a jacket water temperature of 160 degrees F., and cylinder temperatures of 660 degrees F. at 100 percent load and 750 degrees F. at 125 percent load.

pump. The engine blower consists of a pair of toothed rotors revolving together in a closely fitted housing. The air enters the housing at one side and is carried around the cylindrical sides of the housing and is discharged under pressure at the other side through a discharge manifold into the air chamber of the engine. The two centrifugal water pumps are mounted below the blower. One pump forces jacket water through the closed cooling system of the engine. The other of the two pumps forces sea water through the lube oil cooler and then through the jacket water cooler. Water is delivered to this sea water pump either from the booster pump located in the ice machine room or from the fire main through a thermally operated valve. This thermally operated valve is actuated by the jacket cooler temperature and thereby supplies water from the fire main in case the normal supply fails and the cooler temperature rises. The flow of fresh water to the jacket from the fresh water pump is controlled by a temperature regulating valve which maintains a constant temperature in the jacket. Fuel oil is supplied under pressure to the injectors by a pump which is of the positive

Caution

The emergency Diesel generator must be lined up at all times to start automatically when the normal power voltage on both ship's service switchboards falls to 350 volts in the PD-MS class or 290 volts in the DD692 class. Under all circumstances the salt water booster pump, connected with the engine, should be lined up to start automatically as soon as the switchboard is energized. The fire main should never be depended upon to furnish salt water service except in case of a casualty to the booster pump. It should be established routine to start the Diesel generator automatically at least twice a week. When this is done it must be insured that the salt water booster pump is NOT primed from the fire main.

DD692 Class.-The DD692 class is furnished with two of these Diesel generators, one located forward and the other aft. The forward one is connected for automatic starting to the forward ship's service hoard, and the after one to the after board. A description of the electrical hookup for both classes appears in section XII. The after Diesel generator in this class is equipped with a salt water booster pump similar to that in the DD445 class, but the forward Diesel generator is equipped with a Nash type self-priming pump in lieu of the salt water booster pump.

Section XI

OPERATING PROCEDURE

1. LINE UP OF PIPING SYSTEMS FOR SPLIT-PLANT OPERATION

1. *Main Steam*.-Valves MS-4 and MS-15 closed. Have warming up bypass around MS-4 open.

2. *Main Feed*.-Valves MF-3, MF-24, MF-31, and MF-42 closed.

3. *Auxiliary Steam*.-Both valves at after bulkhead No. 1 engineroom closed, others according to boiler line-up.

4. *Auxiliary Exhaust*.-Close bulkhead cut-out valve at after bulkhead, lower level No. 1 engineroom.

5. *Condensate System*.-Crossconnection valves from condensate discharge in each engineroom closed.

6. *Feed Booster System*.-Hot suction to each emergency feed pump lined-up to pump manifold crossconnection between the two enginerooms closed by valve at No. 2 emergency feed pump and valve at after bulkhead No. 1 engineroom. 7. *High-Pressure Drains* .-Crossconnection valve at after bulkhead of No. 1 engineroom closed.

8. *Low-Pressure Drains*.-Crossconnection valve at after bulkhead of No. 1 engineroom closed.

9. *Contaminated Drains*-Crossconnection valve at after bulkhead of No. 1 engineroom closed.

10. *Lubricating Oil System*.-While there is no crossconnection between time lubricating oil service systems, the crossconnection valve

2. PROCEDURE FOR LIGHTING OFF A COLD BOILER, AND CUTTING IN AN ADDITIONAL BOILER ON MAIN STEAM LINE

See Section VI.

Station Breakdown for Lighting-Off Boiler

Watertender (In General Charge)

Start emergency feed pump on cold suction.

Check line-up of fuel oil system.

Start fuel oil service pump.

Bring up air pressure arid blow through furnace.

Close drum and superheater vents as they start to blow steam.

When pressure reaches 50 p.s.i. notify engineroom and cut in superheater drains on H. P. drain line.

Cut in on auxiliary steam when ordered by engineroom.

Shift emergency feed pump to hot suction when ordered by engineroom.

Secure emergency feed when main feed pump is put on line.

Cut-in on main steam when so ordered.

DO NOT BRING UP SUPERHEAT UNTIL SO ORDERED.

between the two purifying systems must be locked closed.

11. *Fuel Oil System*.-Forward service pumps lined up to forward service tanks, and after service pumps lined up to after service tanks: fuel oil transfer crossconnection valve closed unless actually transferring oil.

For Normal Auxiliary Watch Line-Up, the Following Should be Cross connected

1. Auxiliary Steam System.
2. Auxiliary Exhaust System.
3. High Pressure Drains.
4. Low Pressure Drains.
5. Contaminated Drains.

No other systems should be crossconnected on auxiliary watch unless the line-up actually requires it.

Feed Check Man

Jack open the Bailey Regulator.

Run down boiler to 1" in 10" glass.

Raise level 1/2".

Line-up fuel oil discharge through heater and cut-in steam as ordered.

Warm up blowers.

When pressure reaches 500 p.s.i. lift all safety valves by easing gear.

Keep a close watch on the water level as the pressure rises. Blow down if too high.

Assist watertender cutting-in on auxiliary steam.

Assist watertender cutting-in on main steam.

Fireman

Assist in running down boiler.

Assist watertender to line-up and start emergency feed pump.

Line-up fuel oil suction and discharge with circulating valve open.

Assist watertender to start fuel oil service pump.

Cut-in steam to fuel oil heater.

Open drum and superheater vents, and superheater open drains.

Light-off one small burner when fuel oil temperature reads 135 degrees F. Close recirculating valve. Regulate steam to heater, to maintain fuel oil (Navy Special) temperature between 130 degrees F. and 140 degrees F. as ordered.

Light-off another burner as pressure rises and furnace heats up.

3. PROCEDURE FOR WARMING UP MAIN PLANT, SPLIT-PLANT OPERATION

Check oil level and temperature in lubricating oil sump tank. If temperature is below 90 degrees F., admit steam to cooler and recirculate to bring it up. Check and clean strainers.

Run down water from deaerating tank to main condenser, 1/4 to 1/2 glass in hot well.

Line up main condensate system to deaerating tank. Open recirculating valve from deaerating tank. and bypass thermally operated valve.

Warm up and put main condensate pump on line.

Shift high-pressure drains to deaerating tank, and divide high-pressure drain system.

Cut in auxiliary exhaust steam to deaerating tank.

However, on this installation the second-stage jet will draw a vacuum on the main condenser of about 26.5 inches, which is sufficient until the engines are turned over with steam. Therefore it is better to wait until then.

When vacuum reaches 25 inches, shift the Swartwout unloading valve to the main condenser.

Cut in low-pressure drain tank to the main condenser and divide the low-pressure drain system. Do the same for the contaminated drain system.

When the boilers of both plants are on auxiliary line, divide auxiliary steam and auxiliary exhaust.

Warm up and idle main feed pump. Close 2-inch recirculating valve from booster pump and open three-fourths-inch valve.

Notify fireroom and then cut in main feed pump on the line.

Call for main steam from fireroom.

When steam is up to the engineroom. cut out valves, stop engines, and disengage jacking gear. PUT SIGN ON MAIN GAGE BOARD.

Warm up lines and admit steam up to the cruising and h. p. throttles.

Line up turbines on cruising combination.

Get permission from officer-of-the-deck and then spin turbines ahead and astern on cruising and astern turbines to warm up.

If ship's orders require, it may be necessary to shift to the high-pressure combination before reporting ready.

Start and warm up main feed booster pump, with 2 inches recirculating valve open to deaerating tank. Shut down auxiliary booster pump if running.

Line up lubricating oil system. Warm up and put lubricating oil pump on line. Check all bearings for circulation. DO NOT CIRCULATE LUBRICATING OIL UNLESS TEMPERATURE IS AT LEAST 90 degrees F.

Engage jacking gear and start jacking over main engines. PUT SIGN ON MAIN GAGE BOARD.

Start gland exhauster and admit steam to gland sealing steam system.

Fill loop seal through filling line.

Start second-stage air ejector jet.

Start main circulator. This is the latest time the main circulator may be started. It may be started at any time previous to this.

When inter-condenser vacuum reaches 16 inches it is permissible to start the first-stage jet.

On completion of maneuvering, shift generator exhaust to main condenser.

On completion of maneuvering, order fireroom to raise the superheat.

It is not desirable to shift the turbo-generator exhaust to the main condenser until after the completion of maneuvering.

Station Break-Down for Warming Up Main Plant, Split-Plant Operation

Chief Machinist's Mate

In supervisory charge over all operations in engineroom.

Order division of auxiliary steam and auxiliary exhaust systems when fireroom is ready.

Order main feed pump on line and notify fireroom.

Call for main steam from fireroom.

Admit steam to turbine throttles.

Check all systems to see that they are split.

Caution-C.M.M. At. or Junior O.O.W. should always wear the IJV telephone headset when testing

main engines, standing by awaiting bells, and while maneuvering.

Throttleman

Run water down from deaerating tank to main condenser.

Line up main condensate systems upper level, with recirculating system bypassed around thermal valve.

Shift high-pressure drains to deaerating feed tank.

Check lubricating oil system and check all bearings for circulation after pump is started. Check low-pressure alarm and automatic pump controls.

Engage jacking gear and commence jacking over.

Admit steam to gland sealing steam system.

Fill loop seal.

Start second-stage air ejector jet.

When inter-condenser vacuum reaches 16 inches, start first-stage air ejector jet.

Shift Swartwout unloading valve to main condenser and split auxiliary exhaust.

Split auxiliary steam system when both firerooms are on auxiliary.

Split L. P. drains and contaminated drains and cut in L. P. drain tank to main condenser.

Disengage jacking gear while main steam is being cut in.

Assist throttleman to split auxiliary steam and exhaust systems.

Close booster recirculating valve when ordered.

Assist throttleman to disengage jacking gear.

Assist in admitting main steam to throttles and in shifting engine combinations.

Warm up ship's service turbo-generator when ordered.

Log Writer and Messenger

Assist throttleman where possible while maintaining his watch on operating machinery.

Log all pertinent entries and remarks.

Pump Man (Lower Level)

Check oil level in lubricating oil sump tank.

Admit steam to lubricating oil cooler if necessary.

Check water level in main condenser.

Line up main condensate system, lower level.

Put main condensate pump on line.

Start main booster pump and shut down auxiliary booster pump if running. Have 2-inch recirculating valve opened.

Line up lubricating oil system, check strainers.

Put lubricating oil pump on line when oil temperature is not less than 90 degrees F.

Admit steam up to cruising, H. P. and astern throttles.

Line-up turbines on cruising combination.

Get permission from Officer-of-the-Deck and then spin turbines ahead and astern for 15 minutes or until warmed up.

Shift to high-pressure combination (if ordered and report ready.

Spin main engines ahead and astern once each five minutes while standing by, insuring that no way is put on the ship.

MM of the Watch (Upper Level)

Assist throttleman lining up condensate system.

Cut in auxiliary exhaust steam to deaerating tank when ordered.

Open main booster recirculating valve (2-inch) when so ordered.

Assist throttleman to start jacking gear.

Start gland exhauster when ordered.

Assist pump man (lower level) to start main circulator.

Open loop-seal filling line for a moment and then close.

Start main circulator.

Shift Swartwout unloading valve to main condenser when ordered.

Split L. P. and contaminated drains and shift L. P. drain tank to main condenser when ordered.

Warm up and idle main feed pump.

Put main feed pump on line when ordered.

Shift generator exhaust to main condenser when ordered.

Take make up feed when required.

Oiler (Lower Level)

Keep watch on all machinery in operation while pump man is occupied. Also assist pump man whenever necessary.

Clean lube oil strainers and assist in lining up system.

Assist pump man to shift Swartwout valve to main condenser.

4. NOTES ON SECURING MAIN PLANT

Do not secure deaerating tank too soon. While securing there are still a great number of high

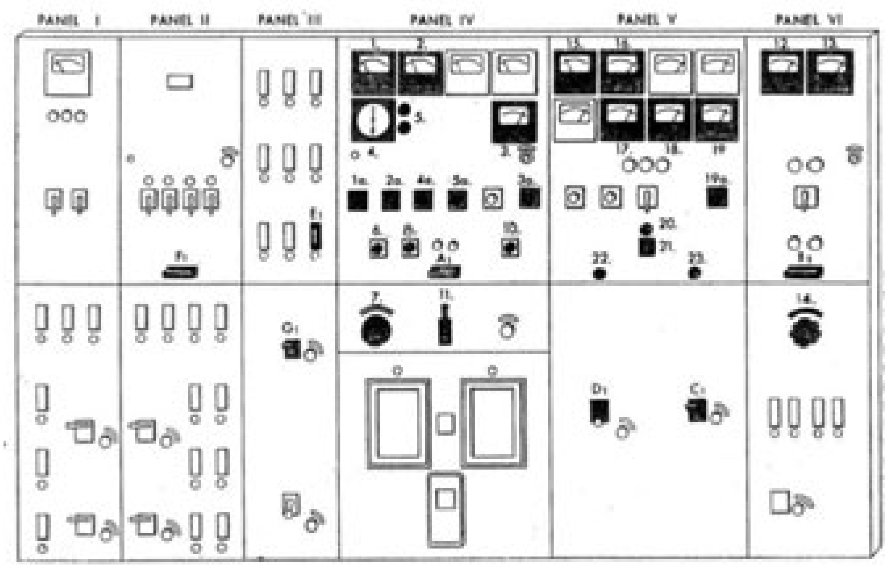
pressure drains and these all going into one tank will cause it to overheat.

Under no circumstances allow the oil temperature to drop below 90 degrees F. until the turbines are stopped jacking and oil is to be cut off from the bearings. This will necessitate shutting off cooling water from the lubricating oil cooler very early.

Do not drop the vacuum on the main condenser too rapidly. It should not be done in less than half an hour.

Do not stop jacking the main engines unless the oil temperature has dropped to at least 100 degrees F.

In order to reduce to a minimum the amount of condensation on the gears of the main reduction gear, it is highly desirable to jack the engines, and continue circulating oil, for two hours after killing vacuum on the main condenser.



PANEL I A.C. LIGHTING AND POWER
PANEL II A.C. BATTLE AND GENERAL POWER
PANEL III RESTRICTED BATTLE POWER
PANEL IV A.C. GENERATOR CONTROL
PANEL V A.C. AND D.C. BUS TIES, CONTROL FOR AFTER GENERATOR
PANEL VI D.C. GENERATOR CONTROL

A1 A.C. Generator Circuit Breaker
B1 D.C. Generator Circuit Breaker
C1 D.C. Bus Tie Circuit Stealer
D1 A.C. Bus Tie Circuit Breaker
E1 A.C. Lighting Circuit Breaker
F1 A.C. Battle and General Power Circuit Breaker
G1 Emergency Generator Bus Circuit Breaker

1. VOLTMETER, #1 A.C. Generator
1a. VOLTMETER SWITCH
2. AMMETER #1 A.C. GENERATOR
2a. AMMETER SWITCH
3. FREQUENCY METER, #1 A.C GENERATOR AND BUS
3a. FREQUENCY METER SWITCH
4. SYNCHROSCOPE
4a. SYNCHROSCOPE SWITCH
5. SYNCHRONIZING LAMPS
5a. SYNCHRONIZING LAMP SWITCH
6. A.C. VOLTAGE CONTROL (MOTOR OPERATED)
7. A.C. VOLTAGE CONTROL RHEOSTAT (MANUAL)
8. VOLTAGE REGULATOR CUT OUT SWITCH
10. GOVERNOR MOTOR CONTROL SWITCH
11. FIELD CUT OUT SWITCH, #1 A.C GENERATOR
12. D.C. VOLTMETER
13. D.C. AMMETER
14. D.C. VOLTAGE CONTROL RHEOSTAT
15. A.C. BUS TIE VOLTMETER
16. A.C. AMMETER AFTER GENERATOR
17. D.C. BUS TIE VOLTMETER
18. D.C. AMMETER AFTER GENERATOR
19. BUS TIE FREQUENCY METER
19a. FREQUENCY METER SWITCH
20. GOVERNOR MOTOR TRANSFER LAMP
21. GOVERNOR MOTOR CONTROL SWITCH, AFTER GEN
22. INDICATING LAMP, A.C. BUS TIE
23. INDICATING LAMP, D.C. BUS TIE

FORWARD GENERATOR AND DISTRIBUTION SWITCHBOARD
DD 445 CLASS
FIG 70

Previous Section DD Steam Home Page Next Section

Section XII

ELECTRICAL PLANT

1. GENERATING PLANT DD445 CLASS

(a) General Discussion.-The DD445 class generating plant consists of two turbine-driven ship's service generating units, located one in each engine room, and one Diesel-driven emergency generator located in the Diesel generator room forward on the starboard side). Each unit has its own switchboard for control of the generator and for distribution of power to the ship's service and emergency power systems.

(b) Ship's Service Units.-Power for the ship's service system is supplied by two 290 kw, turbine-driven generating sets which consist of the following component parts

1. *Turbine and reduction gear*. (See sec. IX.)

2. *AC generator*.-250 kw. 450 volts, 0.80 power factor, 3-phase, 60-cycle, 400-ampere. separately excited with a revolving field.

3. *DC generator*.-40 kw, 120 volts, 333 amperes, stabilized shunt field. This DC generator provides excitation for the above AC generator, in addition to supplying the 120 volt DC power system.

All necessary provisions for controlling the generating sets and for the distribution of power have been incorporated in their respective switchboards. The forward ship's service generator and distribution switchboard is designated as the control switchboard and as such is provided with instruments and controls for the after generator to allow for paralleling and dividing the load from the forward ship's service the field rheostat motor may be operated by a manual control switch on the switchboard and in case of the failure of the field rheostat motor, the rheostat may be operated directly by a manual control located on the switchboard. The voltage of the DC generator does not require automatic regulation and is, therefore, controlled only by a manually operated field rheostat.

(c) Ship's Service Generator and Distribution Switchboards.-Figures 70 and 71 are line illustrations of the forward and after ship's service generator and distribution switchboard, as indicated, is divided into six panels.

Panel I.-AC lighting and power distribution.

Panel II.-AC battle and general power distribution.

Panel III.-Restricted battle power distribution.

Panel IV.-AC generator control panel.

Panel V.-(*Forward Switchboard*) After generator control and AC and DC bus ties. (*After board*) Emergency switchboard and shore connection feeders and AC and DC bus ties.

Panel VI.-DC generator controls and distribution of DC power.

Instruments and switches which are shaded in the illustrations are numbered and the key to these numbers appears on the illustration. It will be noted that the instruments and switches providing the same service on each board have the same number.

switchboard. Normally all paralleling of the generators is done from the forward ship's service switchboard. Since the AC generator voltage is dependent upon the degree of field excitation, a voltage regulator is mounted on each switchboard, which operates automatically to vary the field excitation in order to maintain constant voltage throughout normal changes in load. To do this the voltage regulator operates a field rheostat motor which in turn operates the generator field rheostat to vary the degree of excitation. A stand-by regulator and a transfer switch are also located on each switchboard to provide for automatic regulation in case the regulator in operation should fail. In case of the failure of both regulators,

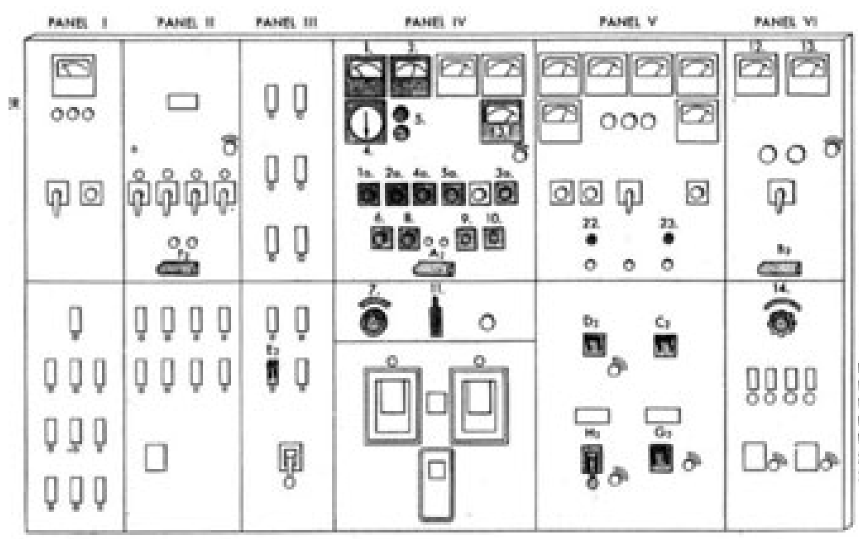
These numbers are used to key the operating instructions later outlined.

(d) Emergency Service Units.-To provide electrical power to certain vital auxiliaries and to provide a limited amount of lighting in the case of failure of the ship's service power, an emergency Diesel generating unit is provided. It consists of the following component parts:

1. *Diesel engine*. (See sec. X.)

2. *AC generator*.-100 kw., 450 volts, 0.60 or 0.80 power factor, 3-phase, 60-cycle, 214 amperes.

3. *Exciter*.-Direct-connected DC generator. 120 volts. shunt-wound.



PANEL I A.C. LIGHTING AND POWER
PANEL II A.C. BATTLE AND GENERAL POWER
PANEL III RESTRICTED BATTLE POWER
PANEL IV A.C. GENERATOR CONTROL
PANEL V A.C. AND D.C. BUS TIES, EMERGENCY SWITCHBOARD AND SHORE CONNECTION FEEDERS
PANEL VI D.C. GENERATOR CONTROL

A2 A.C. Generator Circuit Breaker
B2 D.C. Generator Circuit Breaker
C2 D.C. Bus Tie Circuit Breaker
D2 A.C. Bus Tie Circuit Breaker
E2 A.C. Lighting Circuit Breaker
F2 A.C. Battle and General Power Circuit Breaker
G2 Emergency Generator Bus Circuit Breaker
H2 Shore Power Switch Circuit Breaker

1. VOLTMETER, #2 A.C GENERATOR
1a. VOLTMETER SWITCH
2. AMMETER
2a. AMMETER SWITCH
3. FREQUENCY METER, #2 A .C GENERATOR AND BUS
3a. FREQUENCY METER SWITCH
4. SYNCNROSCOPE
4a. SYNCHROSCOPE SWITCH
5. SYNCHRONIZING LAMPS
5a. SYNCHRONIZING LAMP SWITCH
6. A.C. VOLTAGE CONTROL (MOTOR OPEPATED)
7. A.C. VOLTAGE CONTROL RHEOSTAT (MANUAL)
8. VOLTAGE REGULATOR CUT OUT SWITCH
9. GOVERNOR MOTOR TRANSFER SWITCH
10. GOVERNOR MOTOR CONTROL SWITCH
11. FIELD CUT OUT SWITCH, #2 A.C. GENERATOR
12. D.C. VOLTMETER
13. D.C AMMETER
14. D.C. VOLTAGE CONTROL RHEOSTAT
22. INDICATING LAMP A.C. BUS TIE
23. INDICATING LAMP D.C. BUS TIE

AFTER GENERATOR AND DISTRIBUTION SWITCHBOARD
DD 445 CLASS
FIG. 71

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This Diesel generating unit starts up automatically on failure of the ship's service power system. This occurs within 10 seconds after failure of the ship's service system.

DD445 class ship's emergency power system is arranged to provide automatic transfer of the circuits for the I. C. switchboard and steering power panel. DD692 class ships are arranged for automatic transfer of the steering power panel only.

(*e) Interconnections*.-Figure 72 shows in single switchboard to shore power. This connection is led to a connection box provided on deck so that the ship's service switchboards may be energized from ashore or from another ship. This connection may also be used to supply power, from the after switchboard, to the shore or to other ships alongside.

2. GENERATING PLANT DD692 CLASS

(a) General Discussion.-The arrangement of the DDGO2 class generating plant is essentially the same as that of the DD445 class. However, in order to accommodate the increased ship's service load of

line schematic form the connections between these three generating units and their respective switchboards and the interconnections between the three switchboards. It will be noted that the AC and DC buses on the forward and after ship's service generator and distribution switchboards can ha connected together. This enables one unit to supply power to both ship's service switchboards when the other unit is out of service and also provides a means for parallel operation of the two generating sets. However, under split plant conditions the generators are operated separately, each unit providing power for its own section of the ship. The emergency generator and distribution switchboard is normally energized by the forward ship's service switchboard. Should the voltage at the forward board fall below 350 volts, the feed to the emergency board will automatically transfer to the after ship's service switchboard if the voltage there remains above 405 volts. If neither the forward nor the after ship's service switchboards are energized, the emergency Diesel generator will start automatically and take over the emergency load. When the ship's service power is restored and the voltage on either of the ship's service switchboards rises to 405 volts or above, the emergency load is automatically removed from the Diesel generator and the emergency switchboard again energized from the ship's service board. The Diesel generator is then operating without load. The Diesel engine will not stop automatically, but must be secured manually. Figure 72 shows an interconnection between the emergency generator switchboard and the after ship's service switchboard. This is a "feed-back" connection provided for use when both ship's service generators are secured and when shore or tender power is not available. Through this interconnection the emergency generator may be connected to the ship's service board and supply a limited amount of power to the ship's service system. Figure 72 shows also a connection from the after the ship and to provide sufficient capacity to enable one generator to carry the entire battle load if necessary, the capacity of the ship's service generators has been increased, and an additional Diesel-driven emergency generator has been provided.

(b) Ship's Service Units.-The ship's service power system is supplied by two turbine-driven generating sets consisting of the following component parts:

1. *Turbine and Reduction Gear*. (See sec. IX.)

2. *AC Generator*.-400 kw., 450 volts, 0.80 power factor, 3-phase, 60-cycle, 642 amperes with separately excited revolving field.

3. *DC Generator*.-50 kw., 120 volts, 417 amperes with stabilized shunt field. This DC generator provides excitation for the AC generator in addition to supplying power for the 120 volts DC power system.

(c) Switchboards.-The switchboards for control of the generators and for distribution of power have been rearranged as shown in Figures 73 and 74 but include essentially the same generator controls and distribution system as previously described for the DD445 class switchboards. Five panels appear on these boards, designated as follows:

Panel I.-AC lighting.

Panel II.-AC battle and general power.

Panel III.-AC bus ties and restricted battle power.

Panel IV.-AC generator controls.

Panel V.-DC generator controls, bus ties, and feeders.

It will be noted that the key numbers applied to the instruments on these boards are the same as the key numbers applied on the DD445 class boards.

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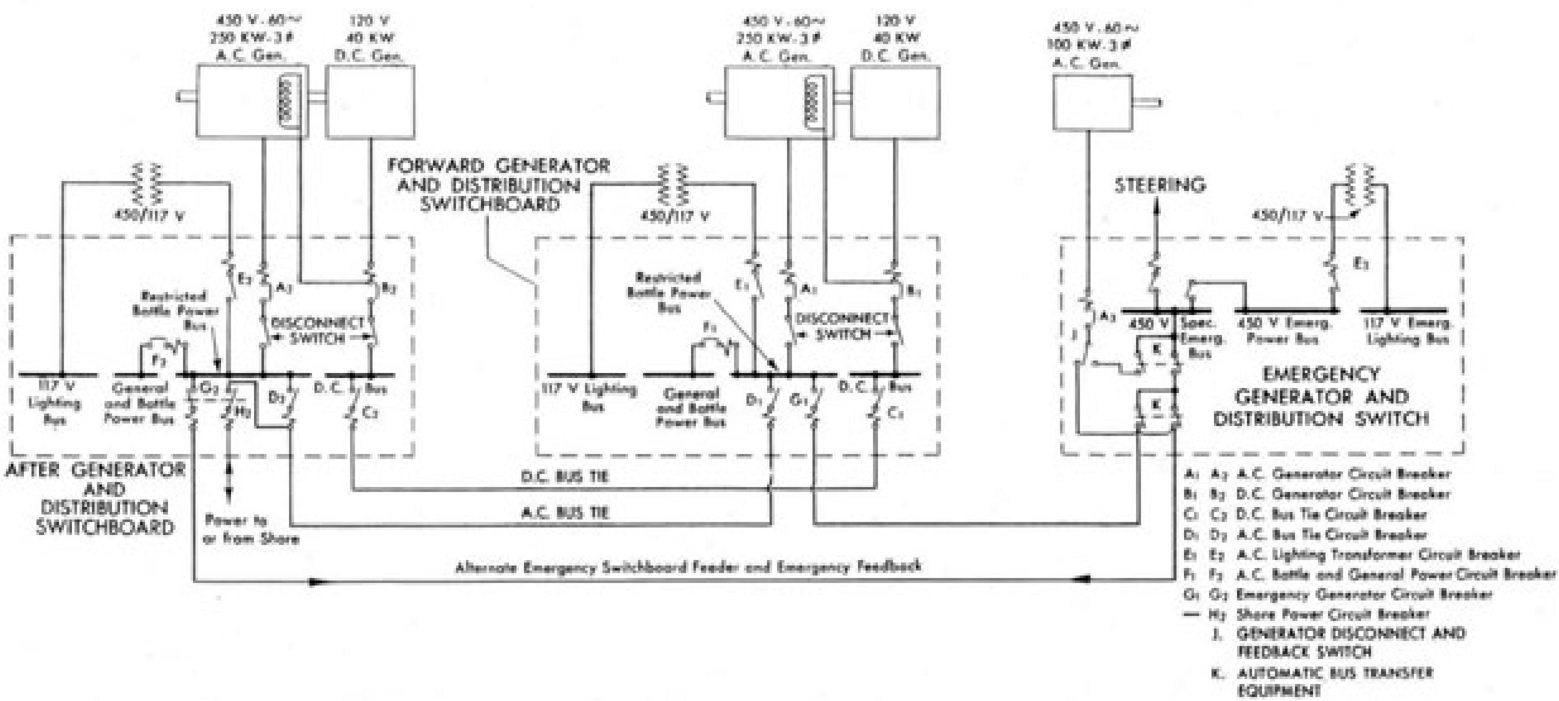

A1 A2 A.C. Generator Circuit Breaker
B1 B2 D.C. Generator Circuit Breaker
C1 C2 D.C. Bus Tie Circuit Breaker
D1 D2 A.C. Bust Tie Circuit Breaker
E1 E2 A.C. Lighting Transformer Circuit Breaker
F1 F2 A.C. Battle and General Power Circuit Breaker
G1 G2 Emergency Generator Circuit Breaker
- H2 Shore Power Circuit Breaker
J. GENERATOR DISCONNECT AND FEEDBACK SWITCH
K. AUTOMATIC BUS TRANSFER EQUIPMENT

DD 445 CLASS
GENERATOR AND DISTRIBUTION SWITCHBOARDS
FIG. 72

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(d) Emergency Service Unit.-Because of the increased ships service and emergency load on the DD692 class, two 100-kw. Diesel emergency generating units have been provided to deliver emergency power. These units are duplicates of those in the DD445 class. One of these is located in the emergency generator room forward and the other is located in the emergency generator room aft. The forward emergency switchboard is normally energized from the forward ship's service switchboard. and the after emergency switchboard from the after ship's service switchboard.

(e) Interconnections.-Figure 75 shows in single line schematic form the connections between the generating units and their respective switch boards and the interconnections between the switchboards. As in the DD445 class. the ship's service switchboards can be connected together to allow one board to provide power for the other a well a to allow for parallel operation of both generating sets. The forward and after emergency generator and distribution switchboards are normally energized from the ship's service switchboard in its own section of the ship. If the voltage on one of the ship's service switchboards should drop to 290 volts or less. the emergency generator of that system will start automatically and provide emergency and lighting to that section of the ship in which it is located. When the ship's service voltage on the ship's service switchboard in question is reestablished, the emergency generator is automatically disconnected and its board again energized from the ship's service switchboard. As in the DD445 class, the Diesel engine must be secured manually. Under no circumstances should the emergency generators be allowed to operate in parallel, and interlocking switches are provided to prevent this. A crossconnection between the emergency switchboards is, however, provided in order to allow for the transfer of emergency power from one emergency generator to the other emergency board to service certain vital auxiliaries. When It is highly desirable that engine room personnel be acquainted with the basic steps in operating ship's service switchboards in order that they may be able to accomplish these operations in the absence of an electrician's mate. As noted in section IX, paragraph 2, each machinist's mate should be capable of single-handedly warming up, cutting in, paralleling, and securing the ship's service generators and switchboards in order to qualify for engine room watches. Under all conditions a qualified electrician's mate should be called as soon as Possible to make final adjustments to the generator switchboards and plant.

(b) Operation of a Single Ship's Service Generator.-This discussion will be started with the generator and distribution switchboard having no source of power, that is, with the DC bus tie switch (*C*) open; the AC bus tie switch (*D*) open, the emergency switchboard feeder switch (*G*) open; and in the case of the after switchboard, the shore power switch (*H*) open. In this condition the engine room would have to be supplied with emergency lighting and power directly from the emergency switchboard or in case the emergency generator is not in operation, lighting only would come from the portable hand lanterns. With the board in this condition the following are the basic steps in placing a ship's service generator in service. Do not start the turbine until the generator controls have been set in the following position:

1. AC generator circuit breaker (*A*) in "open" position.

2. Field cut-out switch (11) in "open" position.

3. AC voltage control rheostat (manual) (7) turned to extreme "lower" position.

4. Voltage regulator cut-out switch (8) in "man" position.

5. DC generator circuit breaker (*B*) in "open" position.

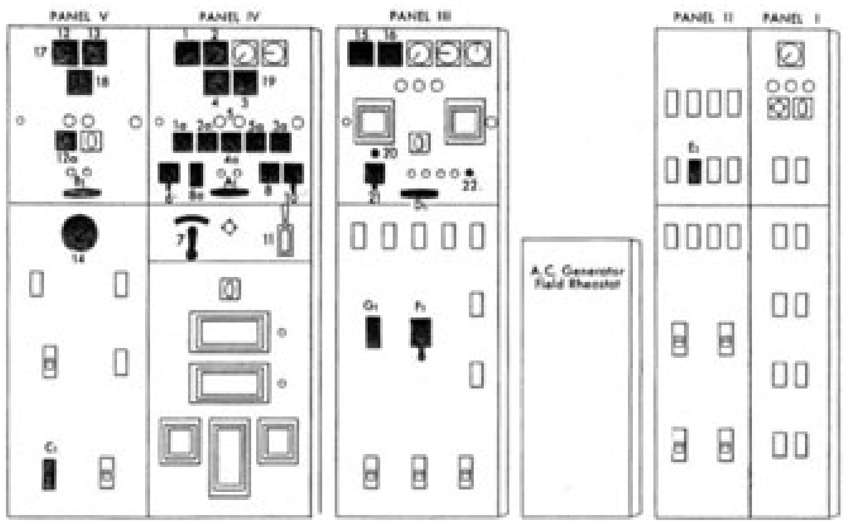
this is done it is not possible to operate the two emergency generators in parallel due to the interlocking switches.

3. OPERATION

(a) General Discussion.-The following discussion of the operation of the ship's service generating plants is provided for the benefit of engineering ratings other than electrician's mates.

6. DC voltage control rheostat (14) in extreme "lower" position.

With the board adjusted as above the turbine may be brought up to approximately its rated speed. Both the DC generator disconnect switch and the AC generator disconnect switch (located behind the switchboard) should now be closed. The DC voltage (12) should now be raised to 120 volts by adjustment of the DC voltage control rheostat (14). The DC circuit breaker (B) should then be closed. This will connect the DC generator to the DC bus. To place the AC



PANEL I A.C. LIGHTING
PANEL II A.C. BATTLE AND GENERAL POWER
PANEL III A.C. BUS TIES AND RESTRICTED BATTLE POWER
PANEL IV A.C. GENERATOR CONTROL
PANEL V D.C. GENERATOR CONTROL, BUS TIES AND FEEDERS

A1 - A.C. Generator Circuit Breaker
B1 - D.C. Generator Circuit Breaker
C1 - D.C. Bus Tie Switch
D1 - A.C. Bus Tie Switch
E1 - A.C. Lighting Switch
F1 - A.C. Battle nod General Power Switch
G1 - Emergency Generator Bus Switch

1. VOLTMETER, #1 A.C. GENERATOR
1a. VOLTMETER SWITCH
2. AMMETER, #1 A.C. GENERATOR
2a. AMMETER SWITCH
3. FREQUENCY METER #1 A.C. GENERATOR AND BUS
3a. FREQUENCY METER SWITCH AND TRANSFER SWITCH
4. SYNCHROSCOPE
4a. SYNCHROSCOPE SWITCH
5. SYNCHRONIZING LAMPS
5a. SYNCHRONIZING LAMP SWITCH
6. A.C. VOLTAGE CONTROL (MOTOR OPERATED)
7. A.C. VOLTAGE CONTROL RHEOSTAT (MANUAL)
8. VOLTAGE REGULATOR CUTOUT SWITCH
8a. VOLTAGE REGULATOR BALANCING LIGHTS
10. GOVERNOR MOTOR CONTROL SWITCH
11. FIELD CUTOUT SWITCH, #1 A.C. GENERATOR
12. D.C. VOLTMETER
12a. D.C. VOLTMETER TRANSFER SWITCH
13. D.C. AMMETER
14. D.C VOLTAGE CONTROL RHEOSTAT
15. A.C. BUS TIE VOLTMETER
16. A.C. AMMETER, AFTER GENERATOR
17. A.C. BUS TIE VOLTMETER (SW. 12a ON BUS)
18. D.C. AMMETER, AFTER GENERATOR
19. BUS TIE FREQUENCY METER (SW. 3a ON BUS)
20. GOVERNOR MOTOR TRANSFER LAMPS
21. GOVERNOR MOTOR CONTROL SWITCH. AFTER GENERATOR
22. INDICATING LAMP, A.C. BUS TIE

FORWARD GENERATOR AND DISTRIBUTION SWITCHBOARD
692 CLASS
FIG 73

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generator in service, the, field cut-out switch (11) should first be closed and then the AC voltage (1) raised to approximately 450 volts by operating the AC voltage control switch (motor operated) (6). The turbine speed should now be adjusted by using the governor motor control switch (10) until the frequency meter (3) is reading 60 cycles. After this is done it will probably be necessary to readjust the DC voltage to 120 volts, since it will change with a change in turbine speed. The voltage regulator may then be placed in service by readjusting the AC voltage to 450 volts, then turning the voltage regulator cut-out switch (8) to the "regulator on" position. The AC generator may now be connected with the AC bus by closing the AC generator circuit breaker (*A*). This energizes panel III, mates to place one of the ship's service generators in service when the switchboard for that generator is energized by the other ship's service generator. This may be because of a casualty to the generator in service or it may be done to get both generators into service, each furnishing power separately to its own board, in order that power on either board may not be lost while the generators are being shifted it is necessary to parallel the new generator with the one in operation before securing the generator in use or before splitting the plant between the two switchboards. The steps to be followed in starting the new generator are the same as those described in the preceding paragraph up to the point of closing the DC generator circuit breaker and the AC generator circuit breaker. Additional care must be exercised, however, as it is necessary to parallel the DC generators and to synchronize the AC generators before they are paralleled. These operations, concerned with

the restricted battle power panel. To energize panels I and II, the AC battle and general power breaker (*F*) and the AC lighting transformer breaker (*F*), must be closed in that order. With all panels energized, power may be distributed to the various units by closing the breakers marked with the units' names on panels II and III and by closing the lighting distribution breakers on the lighting panel I. With power on the switchboard from another source, such as the emergency switchboard shore power connection, or the other generator switchboard the DC generator breaker (*B*) should not be closed without first opening the DC bus tie breaker (*C*) ; and the AC generator circuit breaker (*A*) should not be closed without opening the breaker through which AC power is being supplied. This may be the AC bus-tie breaker (*D*), the emergency generator breaker (*G*), or in the case of the after switchboard, the shore power breaker (*H*). Doing this will, of course, remove power from the switchboard. This power will be off for the period of time necessary to open one switch and close the other. While lighting may be immediately restored, in this ease, it will be necessary to restart all units operating from the power panels having low voltage release controllers. For this reason, it is more desirable to place the generator on the board by first paralleling with the other power source, if possible. If this power source is from the emergency generator or from shore power this will not be possible. But if from the other ship's service generator, it can he done as described in the following paragraph.

(c) Paralleling.-It may at times be necessary for engineering personnel other than electrician's
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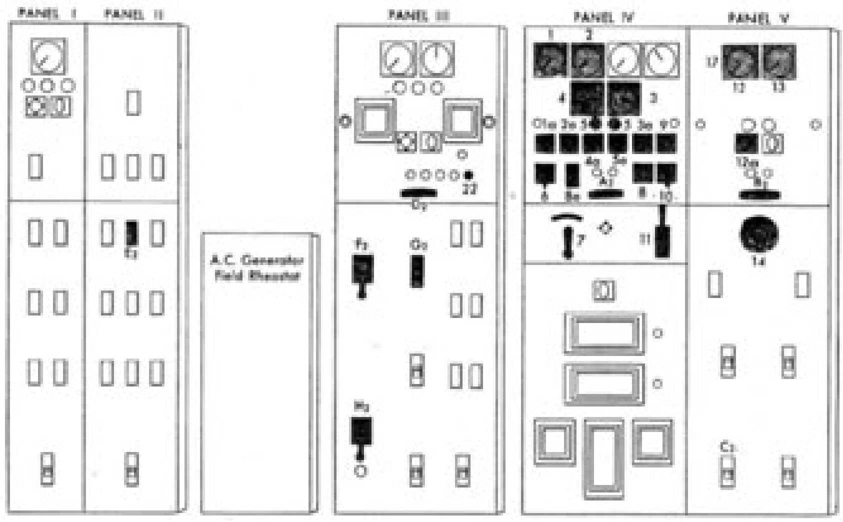
paralleling the generators, may be accomplished from either of the ship's service switchboards but normally they are accomplished from the forward switchboard, since this switchboard carries controls for the after generator. In either case, communication by means of head sets at the switchboards should be established while paralleling. To parallel the DC generators, the DC voltage (12) should be carefully equalized with the DC bus tie voltage (17) before closing the DC generator circuit breaker (*B*). On the DD445 class, if this operation is accomplished from the after board, it is necessary to check the two DC voltages by communication with the forward board since there is no indication on the after board of the DC bus tie voltage. On the DD692 class, the bus tie voltage can be indicated on either board on the DC voltmeter (12) and (17) by using the voltmeter transfer switch (12a). To place a DC load on the new generator the DC voltage control rheostat (14) should be turned to raise the voltage, and the loads equalized by simultaneously checking the load of the two DC generators on the forward DC ammeter (13) and the after DC ammeter (18). Before paralleling the AC generators the speed of the two must be very carefully synchronized. Using the governor motor control switch (10), the generator frequency (3) may be varied until it is equal to the bus tie frequency shown on the same meter (3). The frequency meter switch (3a) is used to switch the same meter back and forth between the



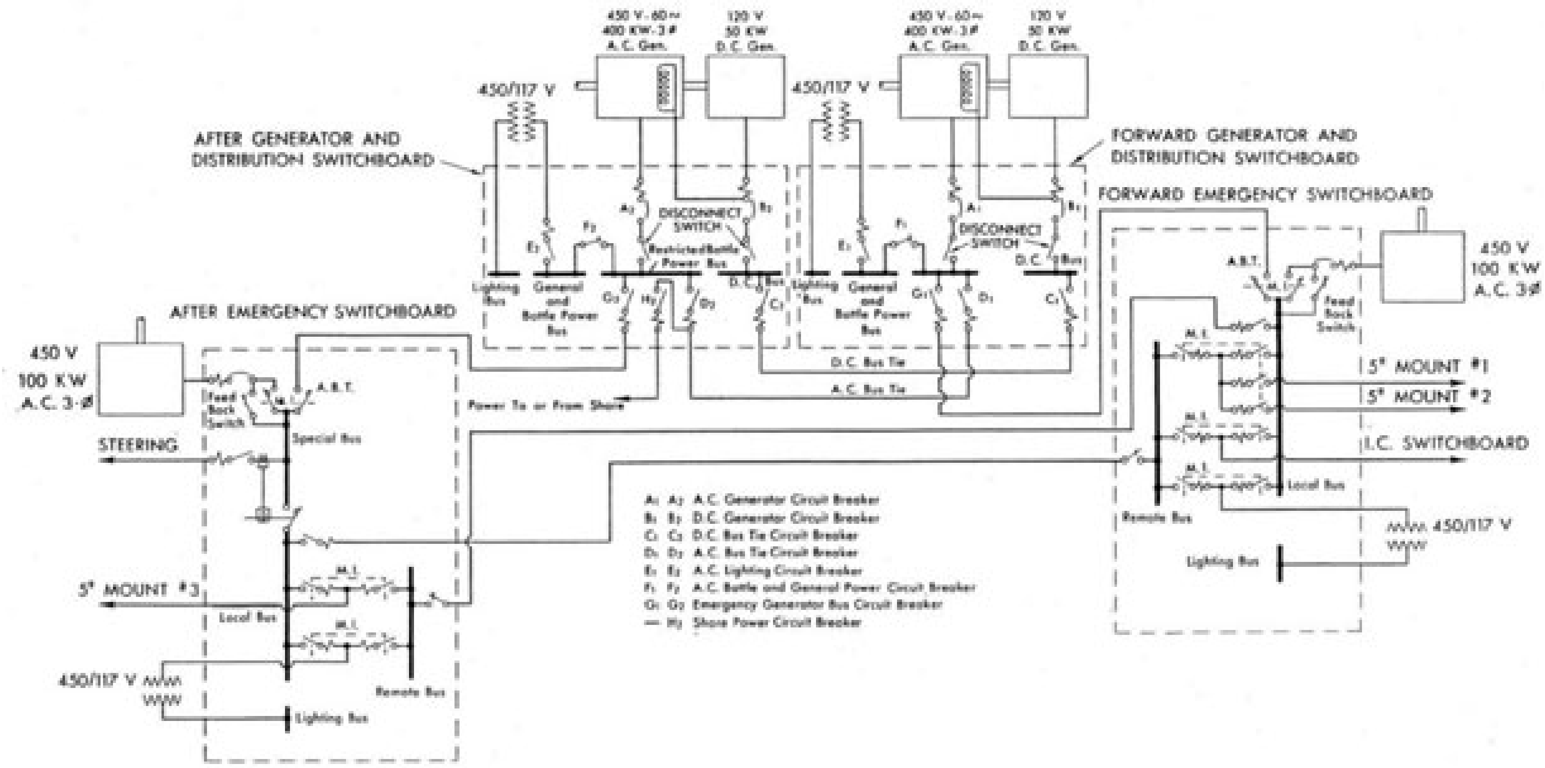
PANEL I A.C. LIGHTING
PANEL II A.C. BATTLE AND GENERAL POWER
PANEL III A.C. BUS TIES AND RESTRICTED BATTLE POWER
PANEL IV A.C. GENERATOR CONTROL
PANEL V D.C. GENERATOR CONTROL, BUS TIES AND FEEDERS

A2 A.C. Generator Circuit Breaker
B2 D.C. Generator Circuit Breaker
C2 D.C. Bus Tie Switch
D2 A.C. Bus Tie Switch
E2 A.C. Lighting Switch
F2 A.C. Battle nod General Power Switch
G2 Emergency Generator Bus Switch
H2 Shore Power Switch

1. VOLTMETER, #2 A.C. GENERATOR
1a. VOLTMETER SWITCH
2. AMMETER, #2 A.C. GENERATOR
2a. AMMETER SWITCH
3. FREQUENCY METER #2 A.C. GENERATOR AND BUS
3a. FREQUENCY METER SWITCH AND TRANSFER SWITCH
4. SYNCHROSCOPE
4a. SYNCHROSCOPE SWITCH
5. SYNCHRONIZING LAMPS
5a. SYNCHRONIZING LAMP SWITCH
6. A.C. VOLTAGE CONTROL (MOTOR OPERATED)

7. A.C. VOLTAGE CONTROL RHEOSTAT (MANUAL)
8. VOLTAGE REGULATOR CUTOUT SWITCH
8a. VOLTAGE REGULATOR BALANCING LIGHTS
10. GOVERNOR MOTOR CONTROL SWITCH
11. FIELD CUTOUT SWITCH, #2 A.C. GENERATOR
12. D.C. VOLTMETER
12a. D.C. VOLTMETER TRANSFER SWITCH
13. D.C. AMMETER
14. D.C VOLTAGE CONTROL RHEOSTAT
17. D.C. BUS TIE VOLTMETER (SW. 12a ON BUS)
22. INDICATING LAMP, A.C. BUS TIE
9. GOVERNOR MOTOR TRANSFER SWITCH

AFTER GENERATOR AND DISTRIBUTION SWITCHBOARD
692 CLASS
FIG. 74



A1 A2 A.C. Generator Circuit Breaker
B1 B2 D.C. Generator Circuit Breaker
C1 C2 D.C. Bus Tie Circuit Breaker
D1 D2 A.C. Bus Tie Circuit Breaker
E1 E2 A.C. Lighting Circuit Breaker
F1 F2 A.C. Battle and General Power Circuit Breaker
G1 G2 Emergency Generator Bus Circuit Breaker
- H2 Shore Power Circuit Breaker

DD 692 CLASS
GENERATOR AND DISTRIBUTION SWITCHBOARDS
FIG. 75

generator arid the bus tie. The synchroscope (4) is turned on by means of the synchroscope switch (4*a*) and the generator speed is again adjusted with the governor motor control switch (10) until the synchroscope indicator is moving very slowly in the "Fast" direction. Just before the synchroscope indicator shows that the generators are in synchronism start to close the AC generator circuit breaker (*A*) so that it will close when the indicator shows exact synchronism of the two machines. In case of the failure of the synchroscope (4) the AC generator may be synchronized by using the synchronizing lamps (5) which can be cut in by the synchronizing lamp switch (5*a*). When using the lamps the AC circuit breaker (*A*) should be closed when both lamps are dark. After the AC generators are in parallel the outgoing generator may be removed by reducing the AC generator load, shown on ammeter (2), by operating the governor motor control switch (10) until the ammeter (2) shows approximately 10 amperes. Then the AC generator circuit breaker (*A*) should be tripped "Open." The DC generator load should then be reduced to zero on ammeter (13) by lowering the DC voltage control rheostat (14). The DC generator circuit breaker (*B*) should then be opened. The turbine of the outgoing generator may now be secured and the frequency of the generator remaining on the line should be adjusted to 60 cycles. If both generators are to be left in operation with the plant split and load divided between the two, the DC bus tie switch (*C*) and the AC bus tie switch (*D*) should be opened (instead of reducing the load and opening the DC and AC breakers) leaving the two switchboards disconnected from each other, each receiving power from its own generator. UNDER NO CIRCUMSTANCES SHOULD THE TWO GENERATORS BE ALLOWED TO CONTINUE OPERATION IN PARALLEL FOR MORE THAN A VERY SHORT PERIOD OF TIME UNLESS AN ELECTRICIAN'S MATE IS PRESENT TO PROPERLY DISTRIBUTE AND EQUALIZE THE LOAD BETWEEN THE TWO GENERATORS. If this is not done serious damage may result. If it is determined by the electrician's mate that it is desirable to continue operating the generators in parallel he may equalize the load by shifting the controls for the after generator to the forward switchboard. This is done by use of the governor motor transfer switch (9) which allows the governor motor control switch (21), for DD445 class or (10) for DD692 class on the forward board to control the after generator.

Section XIII

COURSE OF ENGINEERING INSTRUCTION

It is recommended that a two-hour class of lecture and discussion be held each day. During some other part of the day a conducted inspection of the equipment discussed should be made. Each man should be required to keep a notebook in which to make notes and sketches during the course. These notebooks should be inspected each week when the quizzes are marked.

OUTLINE OF COURSE

First Week

1st day-General outline of course-explanation of steam cycle.

2d day-Arrangement of machinery, manufacturer and type, speeds, location, etc.

3d day-Condensate system-Construction and operation of main condenser, condensate pumps, main air ejector and deaerating feed tank.

4th day-Piping arrangement of condensate system-condensate vents, drains and recirculating.

5th day-Feed system-operation and construction of main feed booster pumps, main feed pumps, and Foster pressure regulating governor.

6th day-Quiz.

Second Week

1st day-Review of quiz. Feed booster pump suction and discharge piping, main feed discharge piping.

2d day-Turbines-construction and layout, throttle valves, crossover valve.

3d day-Gland sealing system, reduction gears and cruising turbine disconnect gear.

4th day-Lubricating oil pumps and controls. Lubricating oil supply and drain piping.

5th day-Lubricating oil settling and purifying system, auxiliary steam system.

6th day-Quiz.

Fourth Week

1st day-Review of quiz; Fuel oil service system.

2d day-Fuel oil transfer system, and fuel oil tank ballast and drain system.

3d day-Ship's service generator and auxiliary plant, low pressure drain tank and H.P., L.P. and fuel oil heater drains.

4th day-Swartwout valve; distilling plant.

5th day-Operation-Plant line-up, divided and parallel. Lighting off and putting boiler on line. Warming up and getting underway; securing.

6th day-General review and discussion.

Quiz-First Week

I. What types are the following steam driven pumps and what mechanisms drive them:

2d day-Make-up and excess-feed system, emergency feed pump suctions and discharge, Bailey feed water level regulator.

3d day-Boilers-superheated and saturated sides, economizer and general construction.

4th day-Blowdown lines, safety valves, soot blowers.

5th day-Fuel oil registers and burners; forced draft blowers.

6th day-Quiz.

Third Week

1st day-Review of quiz-Main steam piping.

1. Fire-and-bilge pump
2. Fuel oil service pump
3. Lubricating oil service pump.
4. Main feed booster pump
5. Emergency feed pump
6. Main feed pump?

II. Which of the above pumps are controlled by a constant pressure pump governor?

III. Roughly sketch a first stage air ejector nozzle and explain its operation.

IV. What is the three-fold purpose of the deaerating feed tank?

V. Make a rough sketch of the loop seal. Explain its purpose and describe its operation.

VI Make a sketch (in section) of the main feed booster pump. Indicate the location of the wearing rings (suction and discharge) and vent connections, and show by arrows the flow of water through the pump.

Alternate Quiz-First Week

I. A. What types are the following pumps

1. Main feed pump.
2. Lubricating oil pump.
3. Main condensate pump
4. Fuel oil service pump
5. Emergency feed pump

B. Which of the above are controlled by constant pressure pump governors?

II. Sketch a first stage air ejector nozzle and explain its operation.

B. What two purposes does the drum pilot valve serve?

C. Why is it necessary for the superheater safety valve to lift before or at the same time as the first drum safety valve?

VII. Sketch the rear view and a cross-section of a fuel oil burner sprayer plate.

Alternate Quiz-Second Week

1. Make a list of details to check before turning over a main feed pump.

III. A. What is the function of the micrometer valve in the Cochrane deaerating feed tank?

B. What is the three-fold purpose of the deaerating feed tank?

IV. Sketch the main loop seal. What is its purpose and describe its operation?

V. A. What is a wearing ring? What purpose does it serve?

B. The speed of the steam main condensate and the steam main feed booster pumps is controlled by what?

C. Condensate from the main condenser is pumped through the main air ejector to serve what purpose?

Quiz-Second Week

I. Why it is desirable to recirculate water from the main feed booster pump discharge back through the deaerating tank for a period of time before feeding to the boilers from the tank?

II. Make a list of details to check before turning over a main feed pump.

III. A. What is an economizer? How does it operate?

B. Why is it necessary to keep a very close watch on the boiler water level when feeding with the Bailey feed water level regulator?

IV. Sketch a boiler in outline, indicating location of saturated furnace, saturated tube nest, superheater furnace, superheater, economizer, all drums and burners.

II. Sketch a boiler in outline, indicating saturated furnace, saturated tube nest, superheater furnace, superheater, all drums, economizer, and location of burners.

III. A. What is an economizer? How does it operate?

B. Why is it necessary to keep a very close watch on the boiler water level when feeding with the Bailey Feed Water Level Regulator?

IV. A. No. 1 emergency feed pump can take suction from where (list all points) ?

B. No. 1 emergency feed pump can discharge to forward feed tanks only when taking suction front where?

V. A. What is meant by the "blow back" of a safety valve?

B. What two purposes does the drum pilot valve serve?

C. Sketch the rear view and a cross-section of a fuel oil burner sprayer plate.

D. List the lifting and reseating pressures of all the safety valves.

Quiz-Third Week

For Ships with 35 p.s.i. Oil system

I. Make a line sketch of the main steam piping, showing the location of all valves.

II. A. List the five steam admission valves of the high pressure turbine, showing into which stage each opens.

B. Sketch the crossover valve. State its purpose and

V. A. No. 1 emergency feed pump can take suction from where (list all points.)

B. No. 1 emergency feed pump can discharge to forward feed tanks only when taking suction from where?

VI. A. What is meant by the "blowback" of a safety valve?

describe its operation.

III. Sketch the gland sealing steam system, indicating all valves. Show which valves are automatic and which hand operated.

IV. What automatic devices control the operation of the lubricating oil service pumps? Describe how the pumps interlock stating pressures involved.

V. A. Which main bearing needle valves can be fully closed?

B. What two features cause a drop in pressure in the lubricating oil supply system from 35 p.s.i. at, the pumps to 10 p.s.i. at the needle valves?

C. How can an empty lube. oil sump tank be tilled when striking down oil from topside?

D. The lubricating oil cross-connection between the two purifier systems must be kept locked to insure against what?

Quiz-Third Week

For Ships With 10 p.s.i. Lubricating Oil System

I. Make a line sketch of the main steam piping, showing location of all valves.

II. A. List the five steam admission valves of the high pressure turbine, showing into which stage each opens.

B. Sketch the cross-over valve. State its purpose and describe its operation.

III. Sketch the gland sealing steam system, showing all valves. Give a summary of its operation, stating at about what speeds the various valves are opened.

IV. A. Describe two methods of shifting from time cruising combination of the main turbines to the high-pressure combination.

B. What automatic devices control the operation of the main lubricating oil pumps? Describe how the pumps interlock, stating pressures involved.

V. A. What effect does fully closing a main bearing needle valve have on the bearing?

B. What two precautions must be taken to protect the turbine rotor before discharging oil to the turbine bearings?

C. How can an empty lubricating oil sump tank be filled when striking down oil from topside?

D. The lubricating oil cross-connection between the two purifier systems must be kept locked to guard against what?

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SS *Forceful*, South Brisbane, Queensland
HMAS *Advance*, Sydney, New South Wales
Commando Boat *Krait*, Sydney, New South Wales
MB172 Epiclass, Sydney, New South Wales
HMAS *Onslow*, Sydney, New South Wales
HMAS *Vampire*, Sydney, New South Wales

HMAS *Whyalla*, Whyalla, South Australia

CANADA

RV *Ben Franklin*, Vancouver, British Columbia

RCMPV *St. Roch*, Vancouver, British Columbia

HMCS *Fraser*, Bridgewater, Nova Scotia

HMCS *Sackville*, Halifax, Nova Scotia

HMCS *Haida*, Hamilton, Ontario

ENGLAND

HMS *Belfast*, London

HMS *Cavalier*, Chatham

FRANCE

FS *Colbert*, Bordeaux

GREECE

B/S *Georgios Averoff*, Athens

ISRAEL

INS *Af Al Pi Chen*, Haifa

INS *Mivtach*, Haifa

NETHERLANDS

HNLMS *Tonijn*, Den Helder

HNLMS *Abraham Crijnssen*, Den Helder

HNLMS *Schorpioen*, Den Helder

Hr. Ms. *Buffel*, Rotterdam

Hr. Ms. *Mercuur*, Scheveningen

NORWAY

M314 *Alta*, Oslo

PERU

BAP *Abtao*, Callao

RUSSIA

Cruiser *Aurora*, St. Petersburg

Soviet *B-413*, Kaliningrad

Icebreaker *Krasin*, St. Petersburg

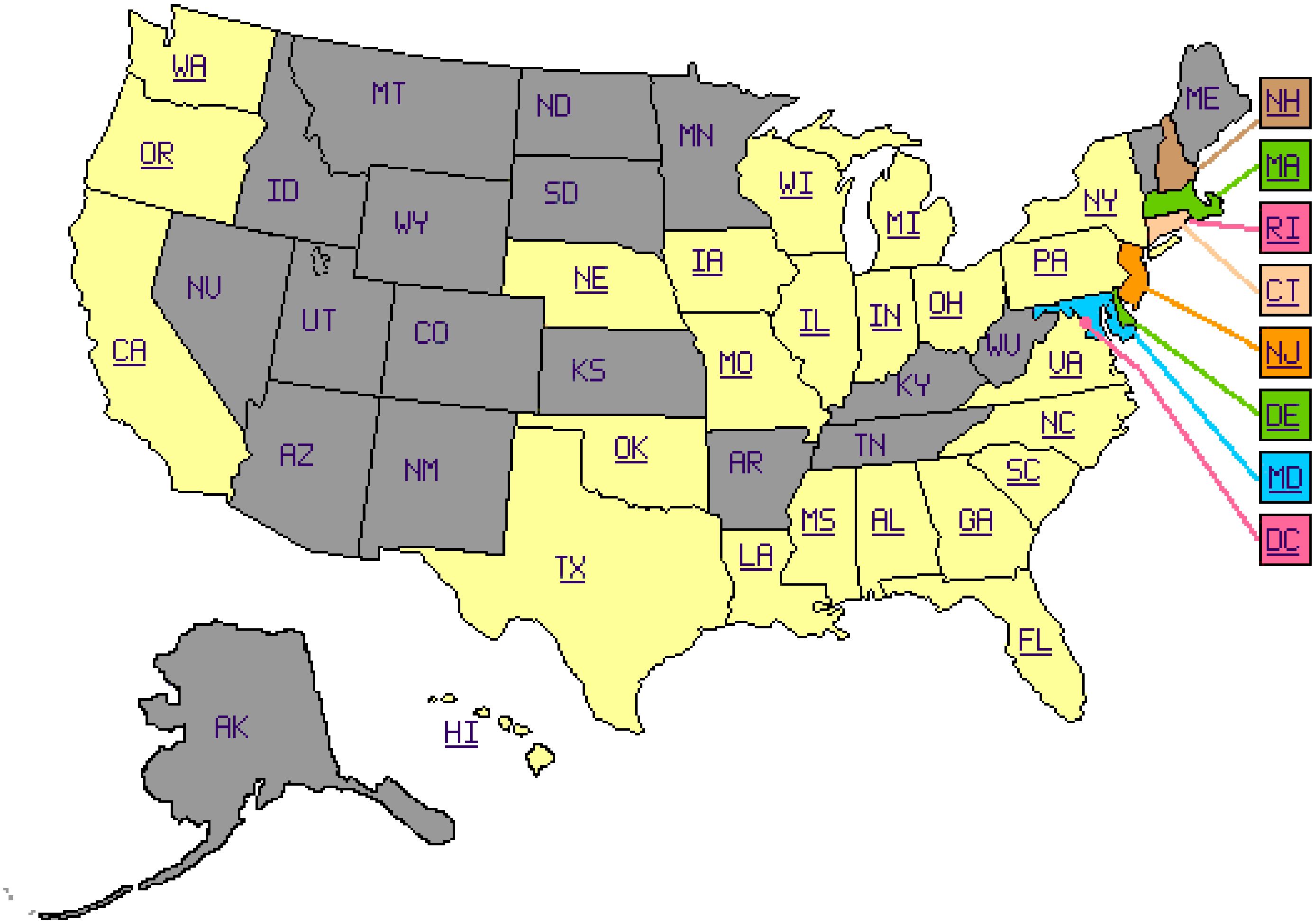
SWEDEN

T121 *Spica*, Stockholm

TURKEY

TCG *Uluçalireis*, Istanbul

UNITED STATES OF AMERICA



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Alabama

USS *Alabama*, Mobile, Alabama

USS *Drum*, Mobile, Alabama

PBR Mark II, Mobile, Alabama

Arkansas

USS *Razorback*, North Little Rock, Arkansas

California

USS *Hornet*, Alameda, California

USS *Potomac*, Oakland, California
Lightship *Relief*, Oakland, California
SS *Red Oak Victory*, Richmond, California
USCGC Fir, Rio Vista, California
PTF 26, Rio Vista, California
USAT *LT-1967*, San Diego, California
Steam Yacht *Medea*, San Diego, California
USS *Midway*, San Diego, California
SS *Jeremiah O'Brien*, San Francisco, California
USS *Pampanito*, San Francisco, California
SS *Lane Victory*, San Pedro, California
PBR Mark II, Vallejo, California

Connecticut

USCG Boat *Icebucket*, Bridgeport, Connecticut
Japanese *HA-8*, Groton, Connecticut
USS *Nautilus*, Groton, Connecticut
Italian *Siluro a Lenta Corsa*, Groton, Connecticut, USA
USS *X-1*, Groton, Connecticut
Auxilliary Schooner *Brilliant*, Mystic, Connecticut
USCGC *Eagle*, New London, Connecticut

Delaware

Lightship *Overfalls*, Lewes, Delaware

District Of Columbia

USS *Barry*, Washington, District of Columbia
LCVP, Washington, District of Columbia
Motor Whaleboat, Washington, District of Columbia
PCF-1, Washington, District of Columbia
RV *Trieste*, Washington, District of Columbia
Continental Gunboat *Philadelphia*, Washington, District of Columbia

Florida

PTF 3, Deland, Florida, USA
PBR Mark II, Orlando, Florida, USA
SS *American Victory*, Tampa, Florida

Georgia

CSS *Chattahoochee*, Columbus, Georgia
CSS *Jackson*, Columbus, Georgia

Hawaii

- USS *Arizona*, Honolulu, Hawaii
- USS *Bowfin*, Honolulu, Hawaii
- Japanese *Kaiten*, Honolulu, Hawaii
- USS *Missouri*, Honolulu, Hawaii
- USS *Utah*, Honolulu, Hawaii

Illinois

- German *U-505*, Chicago, Illinois

Indiana

- USS *LST-325*, Evansville, Indiana

Iowa

- USACOE Dredge *William M. Black*, Dubuque, Iowa

Louisiana

- USS *Kidd*, Baton Rouge, Louisiana

Maryland

- Lightship *Chesapeake*, Baltimore, Maryland
- USS *Constellation*, Baltimore, Maryland
- SS *John W. Brown*, Baltimore, Maryland
- USCGC *Taney*, Baltimore, Maryland
- USS *Torsk*, Baltimore, Maryland

Massachusetts

- USS *Cassin Young*, Boston, Massachusetts
- USS *Constitution*, Boston, Massachusetts
- Tug *Luna*, Boston, Massachusetts
- *Demolition Boat*, Fall River, Massachusetts
- *Hiddensee*, Fall River, Massachusetts
- USS *Joseph P. Kennedy, Jr*, Fall River, Massachusetts
- *LCM 56*, Fall River, Massachusetts
- USS *Lionfish*, Fall River, Massachusetts
- USS *Massachusetts*, Fall River, Massachusetts
- *PT 617*, Fall River, Massachusetts
- *PT 796*, Fall River, Massachusetts
- USS *Salem*, Quincy, Massachusetts
- German *Seehund*, Quincy, Massachusetts

Michigan

- USCGC *Bramble*, Port Huron, Michigan
- SS *City Of Milwaukee*, Manistee, Michigan
- USCGC *McLane*, Muskegon, Michigan
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- USS *Aries*, Brunswick, Missouri

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- USS *Marlin*, Omaha, Nebraska

New Hampshire

- USS *Albacore*, Portsmouth, New Hampshire

New Jersey

- USS *New Jersey*, Camden, New Jersey
- Japanese *Kaiten*, Hackensack, New Jersey
- USS *Ling*, Hackensack, New Jersey
- *PBR Mark II*, Hackensack, New Jersey
- German *Seehund*, Hackensack, New Jersey
- *Fenian Ram*, Paterson, New Jersey
- *Holland Boat #1*, Paterson, New Jersey
- *Intelligent Whale*, Sea Girt, New Jersey

New York

- USS *Slater*, Albany, New York
- USS *Croaker*, Buffalo, New York
- USS *Little Rock*, Buffalo, New York
- *PTF 17*, Buffalo, New York
- USS *The Sullivans*, Buffalo, New York
- MV *Commander*, Cornwall-on-Hudson, New York
- USS *Growler*, New York, New York
- USS *Intrepid*, New York, New York
- USAT *LT-5*, Oswego, New York

Admiral's Barge, Romulus, New York

North Carolina

USS *North Carolina*, Wilmington, North Carolina

Ohio

USS *Cod*, Cleveland, Ohio

SS *William G. Mather*, Cleveland, Ohio

Oklahoma

USS *Batfish*, Muskogee, Oklahoma

Oregon

USS *Blueback*, Portland, Oregon

PT-658, Portland, Oregon

Pennsylvania

U.S. Brig *Niagara*, Erie, Pennsylvania

USS *Becuna*, Philadelphia, Pennsylvania

USS *Olympia*, Philadelphia, Pennsylvania

USS *Requin*, Pittsburgh, Pennsylvania

Rhode Island

Soviet *Juliett 484*, Providence, Rhode Island

South Carolina

USCGC *Ingham*, Mount Pleasant, South Carolina

USS *Laffey* Mount Pleasant, South Carolina

USS *Yorktown*, Mount Pleasant, South Carolina

USS *Clamagore*, Mount Pleasant, South Carolina

CSS *H. L. Hunley*, North Charleston, South Carolina

Texas

USS *Lexington*, Corpus Christi, Texas

Admiral's Barge, Fredericksburg, Texas

Japanese *HA-19*, Fredericksburg, Texas

PT 309, Fredericksburg, Texas

USS *Cavalla*, Galveston, Texas

USS *Stewart*, Galveston, Texas

USS *Texas*, LaPorte, Texas

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Tug *Arthur Foss*, Seattle, Washington
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Schooner *Wawona*, Seattle, Washington

Wisconsin

USS *Cobia*, Manitowoc, Wisconsin
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